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ANNUAL REPORT

of the

Eastern Environmental Radiation Laboratory

January-December 1970

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EERL 71-3	Radiological Survey Around Power Plants Using Fossil Fuel (July 1970) (PB 202-414 $3.00)
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The Cover - Interior of EERL's anechoic chamber used in microwave studies. The anechoic material employs peculiar shapes to break up the impinging wave front and allow absorption of radiation. Flat surfaces would produce reflections which would interfere in calibrating such a facility.

ANNUAL REPORT

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January-December 1970

OCTOBER 1971

ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Monitoring
Eastern Environmental Radiation Laboratory
P. O. Box 61
Montgomery, Alabama 36101

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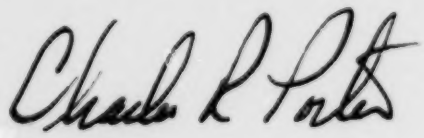
FOREWORD

The Environmental Protection Agency has the responsibility of carrying out a national program for measuring the population exposure to ionizing and nonionizing radiation and for assessing the radiological quality of the environment.

The Eastern Environmental Radiation Laboratory (EERL) contributes to this program through research, applied technology, and training. These endeavors include the development of analytical and radiochemical methodology, and of nuclear facility surveillance technology.

This publication describes the activities of EERL for the 1970 calendar year. It is intended that this report provide the reader an understanding of the various Laboratory programs and an informative discussion of the projects conducted by the Laboratory during the previous year. Comments on this report as well as requests for additional information will be welcomed.

Until December 1970, the EERL was part of the Department of Health, Education, and Welfare and was known as the Southeastern Radiological Health Laboratory. At that time, pursuant to the President's Reorganization Plan No.3, the Laboratory was transferred from the Bureau of Radiological Health, DHEW, to the newly created Environmental Protection Agency and given its present designation. Subsequent references to this Laboratory in the report will use its former name, Southeastern Radiological Health Laboratory or SERHL.



Charles R. Porter
Director
Eastern Environmental
Radiation Laboratory

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Annual Report

of the

Eastern Environmental Radiation Laboratory

January - December 1970

1. INTRODUCTION

As a result of legislation providing for the expansion of radiological health programs, the Southeastern Radiological Health Laboratory (SERHL) was established in Montgomery (dedicated on February 10, 1960) at the facilities formerly occupied by the Communicable Disease Center's Virus Laboratories. It was formed to serve as one of three Regional Laboratories of the Bureau of Radiological Health, a component of the U. S. Public Health Service, in a 15-State area in the southeastern United States and the territories of Puerto Rico and the Virgin Islands. For several years after its inception the Laboratory's emphasis was on ionizing radiation emitted from fallout, x-ray machines, radium sources, etc. Enactment of the Radiation Control for Health and Safety Act of 1968 (PL 90-602) added the responsibility for control of non-ionizing radiation produced by electronic products.

In December 1970, the Environmental Protection Agency (EPA) was formed to bring together in a single organization the major Federal pollution control programs formerly existing in four separate agencies and one inter-agency council. The SERHL became a part of the new Agency's Office of Research and Monitoring which is responsible for much of the Government's efforts for evaluating and controlling radiation in the environment. The SERHL was given responsibility for the eastern United States concerning environmental radiation problems and was renamed Eastern Environmental Radiation Laboratory (EERL), while the Western Environmental Research Laboratory (WERL), also formerly of the Bureau, at Las Vegas is responsible for the western half of the United States.

The current trend toward expanded use of nuclear facilities will place vigorous demands on the Laboratory in

determining the impact of radiation on the environment. In keeping with the national emphasis on controlling pollution in all forms, the Laboratory will be increasingly involved in various pollution control techniques.

SERHL's program during 1970 comprised analytical and radiochemical methodology development, studies in the bioeffects of ionizing and non-ionizing radiation, electronic instrumentation research and development, comprehensive analysis of environmental and food samples for radionuclides, evaluation of relative public health aspects of the siting of nuclear reactors within the regions served by the Laboratory, investigations of the safe use, transport, storage, testing, and disposal of radioactive material, training of personnel from private as well as Government agencies in formal and on-the-job instruction, and various Laboratory support programs.

The SERHL has 76 employees, including 30 professional staff. The facility occupies 28 buildings (45,000 sq.ft.) situated on 11.4 acres, and operates on an annual budget of approximately one million dollars.

Mr. Charles R. Porter was appointed Director of the Laboratory in 1969. Prior to this appointment, Mr. Porter was employed at the Laboratory in various capacities since its inception in 1960. Mr. Charles R. Phillips is the Deputy Director.

Summary of Activities

Significant studies were undertaken by the SERHL during 1970 and were concerned with several areas. Enactment of PL 90-602 led to the initiation of two major projects within the Laboratory - study of microwave biological effects and construction of a calibrated microwave irradiation facility. With the increasing commercial and medical use of microwaves and the need to investigate bio-effects of microwaves, a cytogenetics program was begun. This year saw the formation of the group to conduct these studies and the development of procedures to be used in the primary studies. Initial experimentation showed a significantly higher chromosome aberration rate in irradiated animals than in controls. Other biological studies were concerned with possible damage resulting from the absorption and intake of luminous compounds activated with radioisotopes.

Additional microwave studies awaited the completion of an accurately calibrated microwave irradiation facility. Considerable effort was required in producing one of the few facilities of this type where it is known what maximum limits of error exist on the power output under free field conditions. Two studies looked at the application of fluorescent bulbs and Polaroid film as rapid indicators of excessive radiation emissions from microwave ovens. With additional study, Polaroid film appears feasible for such use.

Another major SERHL program was the formation of a nuclear facilities program. Of two initial studies in this field, one is a feasibility study on the establishment of a national network for monitoring environmental concentrations of ^{85}Kr. Associated with this was the development of a rapid method for determining ^{85}Kr in environmental air samples. One cubic meter of air can be processed in about four hours with 90 percent krypton recovery. A second project is concerned with identifying radionuclides found in an impounded cooling lake for a nuclear power plant and which appear in measurable concentrations within the lake system. These concentrations will be measured and located to indicate where significant inventories of radionuclides occur.

Radiochemistry research conducted investigations in several areas with emphasis on two projects associated with environmental surveillance. A rapid and quantitative method was developed for the determination of actinides in environmental samples. Attocurie amounts of plutonium in high-volume air filters can be determined. Because of the anticipated increase in surveillance around nuclear facilities, development and evaluation studies of radiochemical procedures for this type of sample were conducted.

Lower detection limits of isotopes in water samples from the nuclear facilities program have been employed, while the tritium surveillance system has been expanded. The Environmental Surveillance Networks continue to provide data on environmental radiation exposure.

The radium storage inventory exceeded 56 grams during the year, while an improved photographic leak testing device was developed as was a new radon monitor. The sealed source testing facility was completed for the evaluation of the encapsulation of sealed radiation sources.

Technical training was provided to 391 persons in courses conducted by the SERHL training program. Two new courses were developed - one for high school science teachers and one concerned with surveying for microwave radiation.

Several activities were conducted by the different Laboratory support programs in conjunction with the activities just described, making the year for SERHL a productive one, both in the area of research and in the conduct of its surveillance programs.

2. NUCLEAR FACILITIES BRANCH

Ronald L. Shearin, Chief

The Nuclear Facilities Branch of the SERHL plans, conducts and develops a research program to provide additional knowledge and understanding of the environmental effects of nuclear facilities. It seeks to identify rates of increase and the distribution of environmental ^{85}Kr within the United States. Additionally, it seeks to extend the knowledge of source generation of pollution in the study of a pressurized water reactor and its effect on an impounded cooling lake. It also seeks to identify and develop new environmental surveillance techniques in the course of its study of the cooling lake and in support of environmental studies by other groups.

2.1 MONITORING OF ^{85}KR IN THE ENVIRONMENT

In August 1970 SERHL commenced the development of a nuclear facility studies program. The initial study was to determine the feasibility of establishing a national network for monitoring environmental concentrations of ^{85}Kr, a noble gas fission product prevalent from nuclear facility operations. A rapid method for determining ^{85}Kr in environmental air samples has been developed. The equipment (shown in Fig. 2.1) and the procedure are modifications of previous methods[1,2] employed by other laboratories. The procedure employs charcoal and molecular sieve cold traps, drierite, ascarite and a titanium furnace (900°C) for the removal and separation of other air constituents from krypton. The system components are essentially all metal, thus eliminating many of the breakage problems encountered with glass systems.

---

(1) Sax, N.I., Reeves, R.R. and Denny, J.D., Rad. Health Data and Reports 10, 99 (1969)

(2) Johns, F.B., Southwestern Radiological Health Laboratory Handbook of Radiochemical Analytical Methods, SWRHL-11 (1970) p.58.

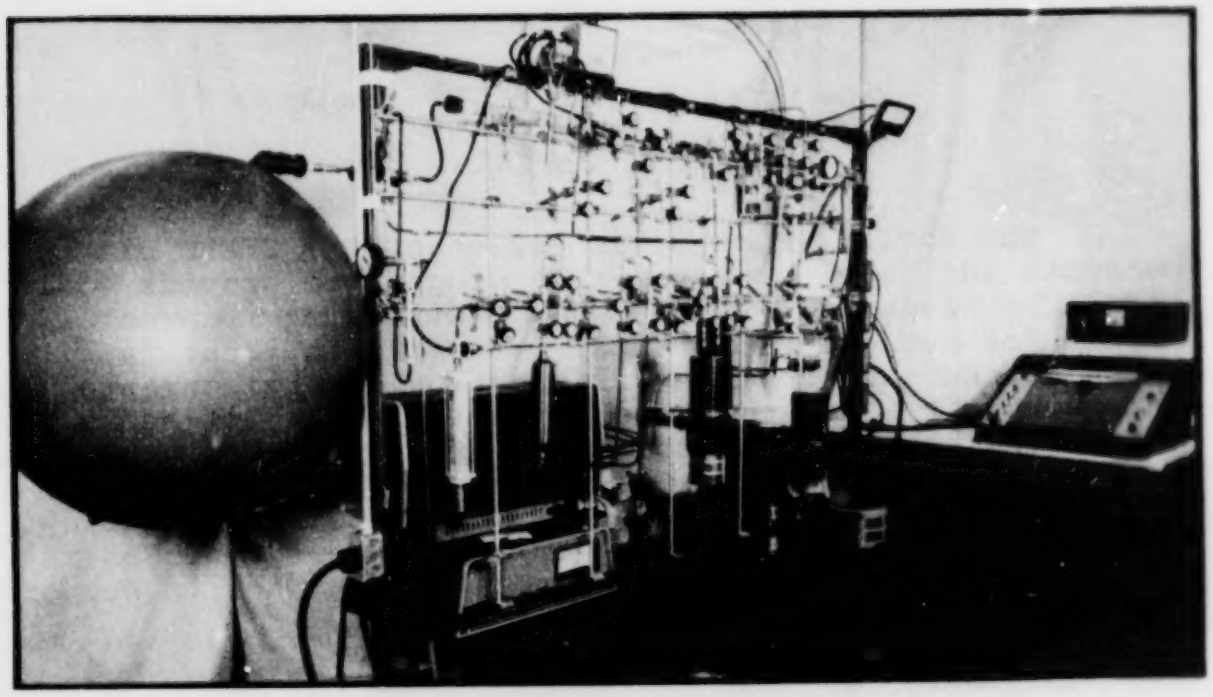

Figure 2.1 ^{85}Kr System for determining ^{85}Kr in air

The major feature of this system as compared to previous systems is the spiking of the air sample with ^{83m}Kr to provide a direct determination of the krypton separation yield. This feature eliminates the need for expensive analytical equipment (such as a mass spectrograph) for determining the purity of the final separation, and the uncertainty in measuring krypton volumetrically when small amounts of other gases are present. Krypton-83m (1.86-hour half-life) is obtained from the decay of ^{83}Rb (83-day half-life) which is an impurity in ^{84}Rb (33-day half-life) solutions.

A ^{83m}Kr generator was developed using a ^{84}Rb solution, that had gone through several half-lives, with its ^{83}Rb impurity. The ^{84}Rb solution was evaporated to dryness in a copper vial and closed to the atmosphere with a bellows high-vacuum cutoff valve and ferrule-type fittings. The vial is plugged with cotton to prevent salt particles of ^{84}Rb and ^{83}Rb from escaping from the vial when the generator is evacuated. The generator is allowed to

equilibrate with two known volumes. One volume is a feference and the ^{83m}Kr in the other is mixed with the air sample. The two volumes are evacuated to less than 5 microns of mercury before equilibration is started.

One cubic meter of air can be processed in about four hours with 80 to 90 percent krypton recovery. The processing time can be reduced if lower krypton recoveries can be tolerated. The procedure is well suited to monitoring environmental air samples with respect to nuclear facilities, such as nuclear reactors and fuel reprocessing plants.

The successful operation of this system has demonstrated the analytical feasibility of determining ^{85}Kr concentrations in air. This technique will be used to analyze compressed air from various parts of the United States, which will demonstrate its application to a national network. Future work will also evaluate the artifacts introduced by various commercial suppliers of compressed air. Additional studies will apply the analytical techniques to specific sources of ^{85}Kr, such as fuel reprocessing plants and power reactors.

2.2 IMPOUNDED COOLING LAKE STUDY

A second study was begun on the impounded cooling lake of the Carolina Power and Light, 700 MW PWR H. B. Robinson Unit #2 at Hartsville, S.C. (see (Fig. 2.2). This study situation was selected due to the concentrating effect of recirculating water from a lake into the cooling cycle and then back into the lake. The water is then available for possible subsequent cycles through the cooling system. Such reuse would tend to magnify concentrations of radionuclides released into the lake. The study is to identify the radionuclides which appear in measurable concentrations within the lake system. The study will measure such radionuclide concentrations and locate areas where significant inventories of radionuclides occur.

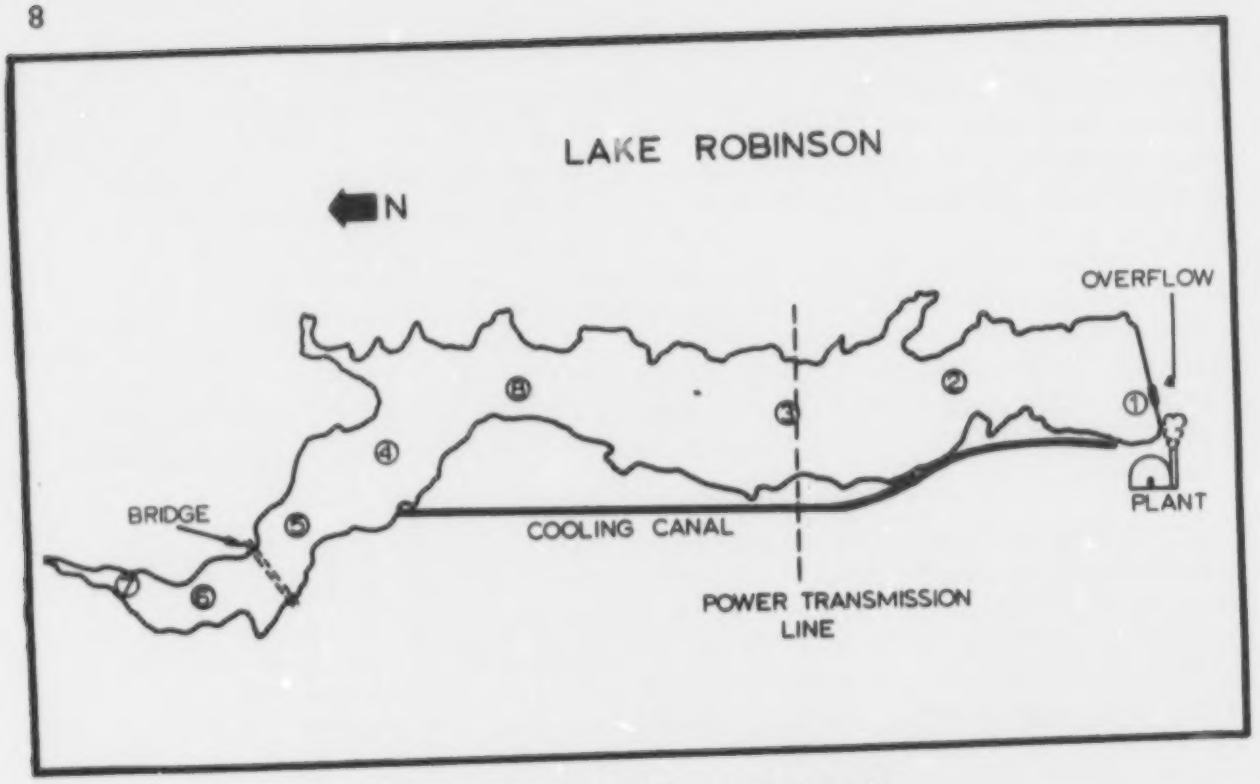

Figure 2.2 Sampling areas in Lake Robinson study

The initial survey of the lake was made on December 1-2, 1970. The plant had begun startup tests in September but had not reached 100 percent power. Lake sampling consisted of two study objectives, the first being a cross-section sampling of surface water, deep water and benthic soil. Eight matched sets of samples were taken down the center of the lake on approximately 1-mile increments from the dam up the 7-mile lake. In addition, the effect of the plant in discharging radionuclides was estimated by passing 200 liters of water from three points through an ion exchange column. The three points sampled were from the cooling water intake, the cooling water discharge to the cooling canal, and the cooling water canal at the discharge to the lake. Aquatic vegetation and fish were also collected.

Initial results have demonstrated measurable concentrations of ^{58}Co in the lake system. The concentrations

varied from less than detectable to a maximum of 4.2 pCi/liter in the lake. Distribution of the radionuclide seems to indicate a thoroughly mixed lake as the plant apparently utilizes the entire lake volume for dilution. Aquatic vegetation acts well as a concentrating marker of radionuclides in the water. Aquatic vegetation at the mouth of the discharge canal contained 6660 pCi ^{58}Co per kg dry weight.

This study will continue as the reactor goes on-line and operates in a relatively steady state for a period of time. An additional study will include mapping the benthic deposits of radionuclides with an underwater gamma scintillation probe.

The second objective was to determine the tritium distribution in the lake. Here 23 sets of surface and deep water samples were taken down the lake center at 1/2-mile intervals with four sets taken to describe the width of the lake. Detailed analyses for this study have yet to be completed.

2.3 OTHER ACTIVITIES

Assistance was given to the Radiological Engineering Laboratory at Cincinnati, Ohio, in their environmental effects study of the pressurized water reactor, Connecticut Yankee, Haddam Neck, Connecticut. Such assistance included developing a procedure using a Field Instrument for Detection of Low Energy Radiation (FIDLER) (Fig. 2.3) to detect the noble gas plume from the gas discharge stack and sampling of the plume by compressed air for laboratory analysis. Other assistance involved utilization of an underwater gamma probe to detect benthic deposits at the mouth of the cooling water discharge on the Connecticut River at Haddam, Connecticut. Such detection directed investigators to the location of maximum concentrations of deposited radionuclides in benthic soils.

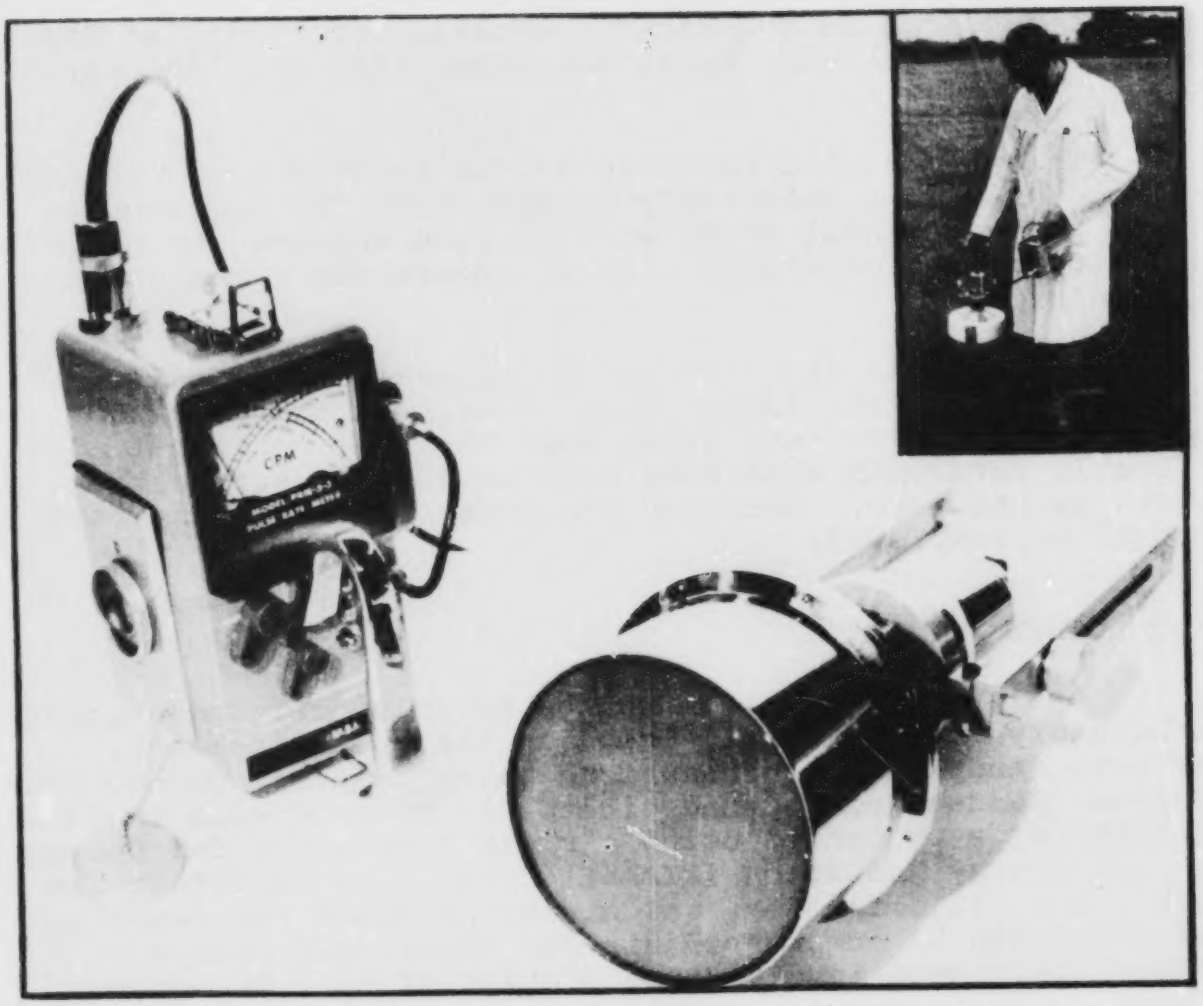

Figure 2.3 Field Instrument for Detection of Low Energy Radiation (FIDLER)

3. ENVIRONMENTAL RESEARCH AND SERVICES BRANCH

Frank E. Butler, Chief

This Branch works closely with the other groups in performing pertinent research and development on projects requiring radioanalytical and stable element determinations. A portion of the group performs routine analytical services in environmental and bioassay surveillance and provides consultative service to other Federal and State agencies. Both the research and routine services personnel perform determinations of radionuclides in the vicinity of nuclear power and fuel reprocessing plants.

During calendar year 1970, the research program developed and improved methodology in a number of selected radionuclides from various types of environmental samples. The analytical services program continued operation of several surveillance networks with increasing interest and effort being focused on support of surveillance around nuclear facilities.

3.1 ANALYTICAL AND RADIOCHEMISTRY RESEARCH SECTION

Robert Lieberman, Supervisor

The Analytical and Radiochemistry Research Section has research and development chemists, research chemical technicians and a stenographer-typist on its staff. The Section's primary function is to provide and maintain up-to-date radioanalytical procedures in support of the various surveillance requirements of SERHL. In order to accomplish this support task the Section has the capability of developing radioanalytical procedures for all radionuclides of interest and from all types of samples. Current radioanalytical procedures already developed are also evaluated for possible use at this Laboratory.

The following studies conducted in 1970 are described in this report:

- Development of a rapid and quantitative method for determination of the actinides in environmental samples.

- Evaluation and development of radiochemical procedures for surveillance around nuclear reactor sites.

- Investigation of biological uptake of radionuclides in industrial applications.

- Improvements of liquid scintillation counting techniques.

- Analytical support for studies involving uptake of ^{3}H and ^{147}Pm from luminous pigments.

3.1.1 DEVELOPMENT OF RAPID QUANTITATIVE METHODS FOR ACTINIDES IN THE ENVIRONMENT

As a result of nuclear weapons testing, isotopes of plutonium, namely, ^{239}Pu and ^{240}Pu, are present in man's environment.

The further use of plutonium in SNAP electric power generators designed for satellite and other applications in outer space has resulted in deposition of significant amounts of ^{238}Pu in the atmosphere. The destruction of SNAP 9-A in the atmosphere in 1964 deposited most of the ^{238}Pu detected to date.

Initial development work was begun to monitor environmental samples at Cape Kennedy for ^{238}Pu. Later methods were developed to determine both ^{239}Pu and ^{238}Pu in all samples of the biosphere to give this Laboratory the capability of assessing worldwide accumulation of these isotopes and the dose to the general population.

Methods were developed for determination of attocurie amounts of plutonium in high-volume air filters. This was extended to analysis of seawater, biological samples, and soils. A paper was presented describing the analytical techniques and initial data for the northern and southern hemispheres.(1) Data of the ^{238}Pu and ^{239}Pu concentrations in air are as follows:

---

(1) Butler, F. E., Strong, A. B., Lieberman, R., "Rapid Determination of Plutonium in Environmental Samples" presented at 16th Annual Bioassay & Analytical Chemistry Meeting, Bethesda, Md., Oct. 8-9, 1970.

Comparison of Plutonium in Air

Location		Date	Number Analyzed	aCi/m^3 Pu-238	aCi/m^3 Pu-239
Montgomery, Ala.	(SERHL)	1970	8	19	123
Sterling, Va.	(HASL)	1969	8	20	61
Miami, Fla.	(HASL)	1969	9	12	49
New Orleans, La.	(NERHL)	1969	1	14	58
Gastonia, N.C.	(NERHL)	1969	1	13	58
South America	(SERHL)	1970	10	11	30
South America	(HASL)	1969	65	17	17

It should be noted that ^{238}Pu results for 1970 samples reported at SERHL were similar to the 1969 values from other laboratories. However, these limited data show a possible increase of ^{239}Pu concentrations in both hemispheres in 1970.

Figure 3.1 illustrates a typical spectrogram of a processed air sample showing ^{238}Pu and ^{239}Pu present and the ^{236}Pu tracer added to determine chemical yield for that sample. The spectrogram shows the resolution obtained in processing an air filter through the coprecipitation step with 0.1 mg of lanthanum fluoride.

Future studies will involve development of methods for all actinides. One example is the analysis of ^{237}Np in fish and water downstream from a nuclear reprocessing facility. Two liquid ion exchangers will be employed for the sequential analysis of Pu, Np, U and the trivalent actinides.

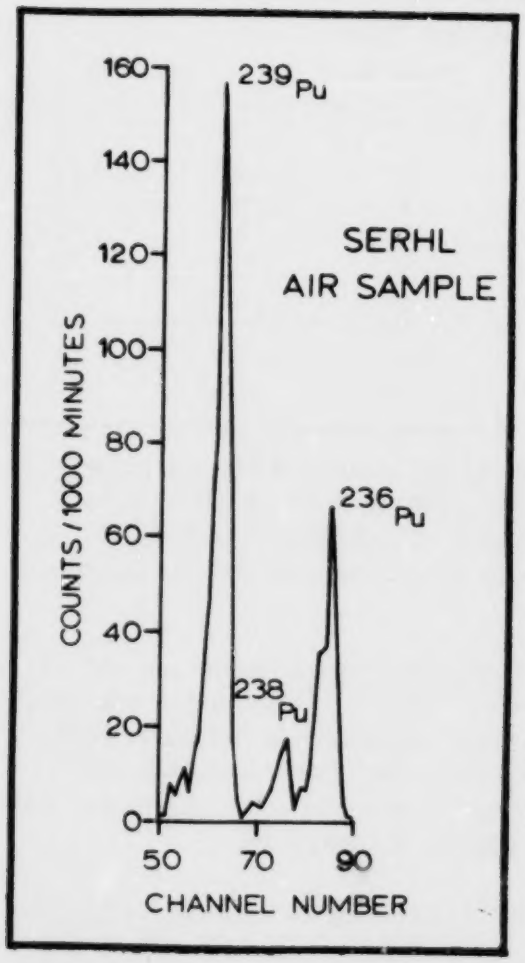

Figure 3.1 Alpha spectrogram of a processed air sample.

3.1.2 EVALUATION AND DEVELOPMENT OF RADIOCHEMICAL PROCEDURES FOR SURVEILLANCE NEAR NUCLEAR REACTOR SITES

The expected proliferation of nuclear power reactors and fuel reprocessing plants over the next several decades is of some concern to environmental scientists. The release of any radioactivity as fission and activation products from these installations to the biosphere will be closely watched by responsible governmental and industrial agencies. To be of any value, the monitoring program must be initiated early enough at each proposed site to establish background levels of radionuclides of interest in order that even the smallest increases in operational radioactivity levels can be detected.

During 1970 this Section initiated a cooperative effort with the Radiological Engineering Laboratory (REL) at Cincinnati. Involved was the testing and evaluation of a number of radiochemical procedures for separation of individual and selected groups of radionuclides from environmental samples. The procedures were gathered from the literature by REL and improved upon by that laboratory. The procedures were then forwarded to SERHL. To date 14 procedures have been evaluated at SERHL and further modifications have been made on 11, based on experimental results obtained. These changes were transmitted to REL for evaluation.(2)

Several cross-check samples originating from the Connecticut Yankee nuclear power reactor were analyzed by both laboratories. In addition, synthetic samples made by the Office of Quality Control at SERHL were analyzed by both laboratories. Complete evaluation of the radioanalytical results is now underway.

Preliminary results indicated good agreement on all of the radionuclides analyzed. The tritium values obtained by REL were higher than those of SERHL. The problem is being resolved by a cross-check program.

A total of approximately 40 individual radiochemical procedures are operational for use with the samples encountered. This does not include procedures being developed for actinide analysis.

3.1.3 INVESTIGATION OF THE BIOLOGICAL UPTAKE OF RADIONUCLIDES USED IN INDUSTRIAL APPLICATIONS

For the past several years, SERHL has been involved in a cooperative program with the 3M Company in developing better methods for bioassay of ^{147}Pm. The project was concluded during 1970.

Industrial employees actively working with ^{147}Pm were monitored by means of radioassay of urine and fecal

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(2) Rapid Cr and Ru Procedures for Environmental Samples - to be published.

samples at frequent intervals. Rapid radiochemical methods for separation and measurement of ^{147}Pm were developed utilizing the bioassay samples made available from these employees.

The methodology developed for ^{147}Pm analysis was rapid, uncomplicated and accurate. Promethium-147 was precipitated directly from urine samples and from fecal ash as the oxalate using neodymium as a carrier. The separated oxalate was dissolved in aqueous disodium EDTA. The resultant solution was counted by liquid scintillation.

The counting efficiency for ^{147}Pm by this method was 80 percent with a background of approximately 20 cpm. The minimum detectable activity for ^{147}Pm in urine was 2.0 pCi/liter and for fecal ash was 2.5 pCi/gram ash.

During the course of the surveillance, ^{147}Pm levels in urine ranged from <2 to 10 pCi/liter and the levels in fecal ash were between <2.5 to 305 pCi/gram.

No attempt was made to correlate the results obtained to body burden levels of the radionuclide. The fact that the workers were actively working with ^{147}Pm throughout the period of bioassay made any such estimate of body burdens difficult.

Because of the higher activity found in the fecal samples, such samples are more sensitive to ^{147}Pm uptake than urine specimens. Body burden assessments could not be made because the subjects involved in the study were continuously exposed to uptake of the radionuclide. The bioassay samples did not reflect true body burdens under those conditions.

Through cooperation with and requests from individual State health departments a variety of samples were radioassayed for other radionuclides. The samples included biota, smears, bioassay and air filter samples which were analyzed for ^{3}H, ^{63}Ni, ^{90}Sr, ^{137}Cs, and ^{226}Ra. The latter three radionuclides were monitored in urine samples submitted by industrial employees of one company currently exposed to these radionuclides.

Levels of ^{90}Sr in urine ranged from 1 to 100 pCi/24 hours corresponding to an estimated body burden of .03 μCi ^{90}Sr for the highest level found. The maximum level of ^{137}Cs found was 1300 pCi/24 hours corresponding to an estimated body burden of .15 μCi ^{137}Cs. The Maximum Permissible Body Burdens (MPBB) for ^{90}Sr and ^{137}Cs are 2.0 and 30.0 μCi, respectively. Strontium-90 analyses were carried out using the procedure for analysis of urine developed at SERHL.(3)

Radium-226 levels in several urine specimens submitted for this purpose were measured utilizing a rapid radium procedure developed for urinalysis. Radium-226 levels were calculated from radon-222 counting. A maximum concentration of 4.0 pCi of ^{226}Ra per liter of urine was found in these samples (MPBB for ^{226}Ra is 0.1 μCi).

The participation of SERHL in these programs provided useful data in cross checking and improving the analytical procedures available for the radioanalysis involved.

3.1.4 IMPROVEMENT OF LIQUID SCINTILLATION COUNTING TECHNIQUES

An investigation was undertaken to improve the sensitivity of liquid scintillation counting of ^{3}H in aqueous samples. The increased sensitivity could not be at the expense of simplicity of handling samples, accuracy or stability of mixtures.

The investigation of emulsion systems for the low-level liquid scintillation counting of tritium was completed and published.(4) A number of commercially available detergents were evaluated and their performances at ambient temperatures were checked.

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(3) Cahill, D. G. and Lindsey, G. K., Anal. Chem. 38, 639 (April 1966)

(4) Lieberman, R. and Moghissi, A. A., International Journal of Applied Radiation and Isotopes 21,319-327 (June 1970)

Performance of each detergent-water-scintillator mixture was rated by measuring tritium counting efficiency and comparing the value with the amount of tritiated water incorporated in the sample. The comparative value was the product of E x V, where E = tritium counting efficiency and V = ml of tritiated water in the emulsion. The largest E x V values of approximately 2.2 were measured with a mixture using p-xylene as the primary scintillator and nonyl phenylpolyethylene glycol ether as the emulsifier.

After establishing the optimum emulsion mixture, the system was standardized for use at SERHL for routine counting of environmental levels of tritium.

The following scintillation mixture has been used routinely for two years at SERHL:

p-xylene	1000 ml
PPO	7.0 grams
bix-MSB	1.5 grams
Triton N-101	363 ml

The xylene to Triton N-101 ratio is 2.75 to 1 and the resultant scintillation solution will incorporate 40 percent water at 20°C. The tritium counting efficiency is 22 percent (background = 9.5 cpm) while the minimum detectable activity for tritium under routine counting conditions is 200 pCi/liter.

The emulsion system has also proven useful in counting a number of alpha and beta emitters in a variety of solutions including the extensive work with ^{147}Pm.

3.1.5 GEL COUNTING BY LIQUID SCINTILLATION

During the past year, improvement was made on a liquid scintillation gel mixture for suspending insoluble radioactive solids to be counted by liquid scintillation.(5)

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(5) Lieberman, R., Williams, M.W. and Pepper, E.W. Health Physics 21(2),326-7 (Aug. 1971)

The principle of this counting procedure is based on the fact that insoluble solids can be radioassayed by liquid scintillation counting as long as they are uniformly dispersed throughout the counting medium.

The gel, based on the reaction between an amine and a diisocyanate, is superior to previously reported systems of this type in that it has a lower order of toxicity and is much easier to handle routinely in a laboratory.

3.1.6 ANALYTICAL SUPPORT FOR STUDIES INVOLVING UPTAKE OF TRITIUM AND PROMETHIUM-147 FROM LUMINOUS PIGMENTS

Urine and fecal samples from experimental animals were submitted to the radioanalytical section for analysis.

Tritium measurements were made utilizing the emulsion-type liquid scintillation mixtures available at SERHL. It was possible to count urine samples directly without distillation by using the internal standard system developed earlier at SERHL.[6] Fecal samples were digested and aliquots were counted for tritium.

Promethium-147 analyses in urine and fecal samples were carried out using procedures developed with the industrial utilization project discussed earlier. Because of the large number of samples handled during the project, the necessity for rapid, accurate procedures was of prime importance.

Radiochemical manipulation of the samples was reduced to a minimum by precipitating the ^{147}Pm from urine and solubilizing fecal ash samples as the oxalate using neodymium carrier. This was in turn solubilized in disodium EDTA and counted by liquid scintillation.

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(6) Moghissi, A. A., and Carter, M. W., Analytical Chemistry 40, 812 (April 1968).

3.2 ANALYTICAL SERVICES SECTION Ann B. Strong, Supervisor

The analytical Services Section is primarily concerned with the radiation surveillance of the environment. This includes an evaluation of radiation levels due to nuclear power reactors and fuel reprocessing plants as well as some continued world-wide fallout. The section also provides analytical support to research and development projects conducted by other groups at the Laboratory.

The facilities operated by this Section include a well-equipped nuclear radiation counting facility containing multichannel gamma analyzers, low-background beta counters, internal proportional counters, liquid scintillation counters and an alpha spectroscopy system. (See Figs. 3.2A-B-C)

The chemical laboratories are set up for solid ion exchange analysis, liquid ion exchange analysis, wet chemistry, and atomic absorption spectroscopy. A variety of sample media which includes air, water, milk, food, bone, vegetation, soil, silt and biota are routinely analyzed for such radionuclides as

strontium-89	ruthenium-106	zinc-65
strontium-90	cesium-137	cobalt-58
radium-226	cesium-134	cobalt-60
cerium-144	chromium-51	manganese-54
iodine-131	thorium-232	potassium-40
barium-140	bismuth-214	iron-59
uranium-238	plutonium-238	zirconium-niobium-95
uranium-234	plutonium-239	

Concentrations of numerous stable elements are also determined.

The Environmental Surveillance Networks continue to provide data on environmental radiation exposure.

3.2.1. PASTEURIZED MILK NETWORK (PMN)

The network consists of 63 stations located in the 50 States, Puerto Rico and the Canal Zone (20 SERHL stations). Milk samples were collected and submitted to the Laboratory

Figure 3.2 SERHL counting facilities consist of gamma spectrometers, G-M and proportional counters and liquid scintillation detector.

Figure 3.2A A portion of the counting facility area containing the air monitor detector and the alpha spectrometer.

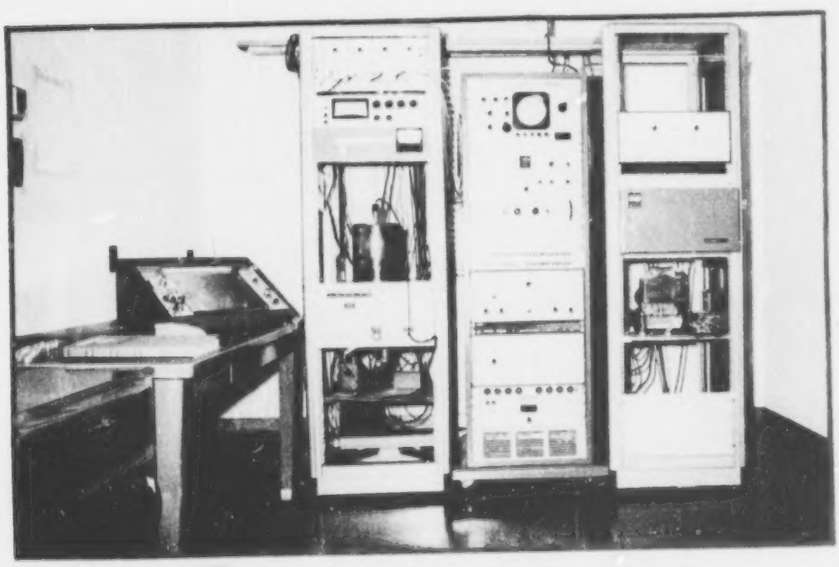

Figure 3.2B Alpha spectrometer

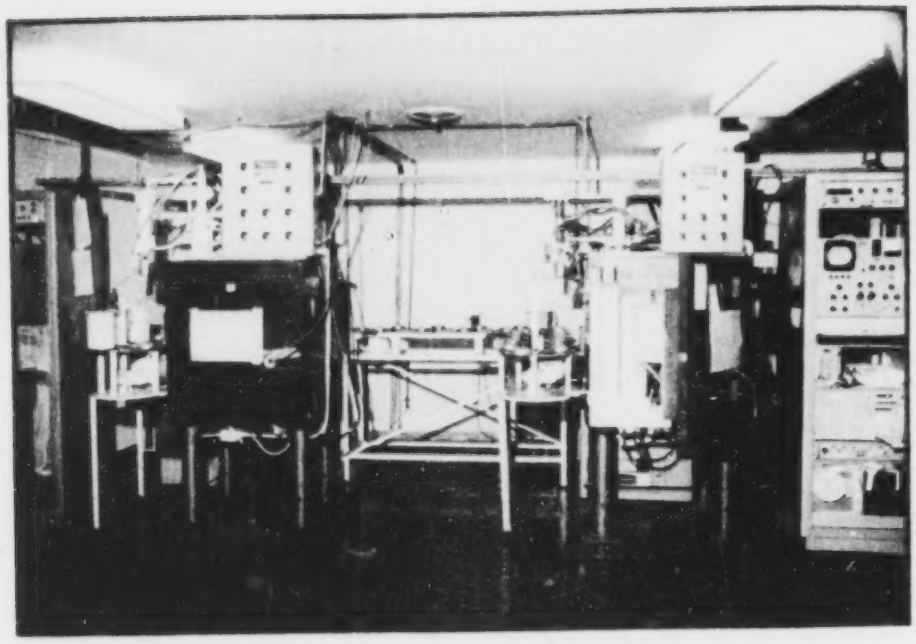

Figure 3.2C Gamma Analyzers

for gamma and specific chemical analyses each week for the first half of the year. In July 1970, collection frequency was reduced to a monthly basis. Six hundred nineteen milk samples were gamma scanned and chemical analyses for strontium-90 and strontium-89 were performed on 236 of these samples. No fresh fission products (^{131}I, ^{140}Ba, ^{89}Sr) were found in any of the samples analyzed by the SERHL. A paper entitled "Evaluation of the Rapid Field Method for the Collection of Radionuclides from Milk" was presented at the Annual Health Physics Society Meeting in Chicago June 28 - July 2, 1970.

3.2.2 INSTITUTIONAL TOTAL DIET STUDY NETWORK

The network provides a continuous measurement of radionuclides in the total diet of a select population group. A weekly diet is collected and sent in from each of 20 institutions housing 9- through 12-year-old boys and girls. Seven of these institutions are SERHL collection sites. During the first six months, diets were collected monthly, but since radionuclide levels in food had become relatively stable, the collection frequency was changed to quarterly. In 1970, 79 samples (66 food, 6 milk, and 7 water) were collected and analyzed.

3.2.3 ADDITIONAL PROJECTS

In 1960 the Drinking Water Analysis project was initiated to determine the radioactive content of interstate carrier water supplies for comparison with PHS drinking water standards. In 1970 this Laboratory analyzed 10 regular interstate water samples and 42 samples from the special community water study conducter in cooperation with the Bureau of Water Hygiene.

As a result of increasing numbers of nuclear facilities, the tritium surveillance system was expanded this year and the SERHL was responsible for 21 drinking water, 10 surface water, and 8 precipitation stations. A total of 187 (58 drinking water, 69 surface water, and 60 precipitation) samples were analyzed for tritium. At the present, levels of tritium are near or below the detection limit of 0.2 nCi/l.

Dated krypton gas samples were analyzed to monitor the buildup of krypton-85 in the atmosphere. Results from these samples confirm the predicted increases of this nuclide.

Data from all these networks are compiled on a routine basis and published in Radiological Health Data and Reports.

In support of the Lake Robinson surveys conducted by the Nuclear Facilities Branch, personnel were trained to handle specific analyses for some 18 different nuclides. Concentration techniques were employed to lower the detection limits of isotopes in water samples. For the first survey 44 water samples were collected for tritium analysis and 16 water samples for complete analysis, including gamma, gross alpha and gross beta, strontium-90, specific radioactive cobalt, and 10 stable elements. In addition, 3 vegetation samples; 9 soil and silt samples; and 8 fish samples were analyzed.

Bone data from the first phase of the Sr-Ca Ratio in Human Bone study are being correlated with Pasteurized Milk Network data and Institutional Total Diet Sampling Network with relation to age, sex, and geographical location.

Environmental technical assistance in the operation of surveillance programs was provided to State, Federal, and international agencies. These included programs for the Pan American Health Organization, Canal Zone, Puerto Rico, Okinawa, TVA, and AEC Miracle Play Project.

4. RADIATION BIO-EFFECTS BRANCH

James M. Everts, Ph.D., Chief

The SERHL represents a complete laboratory in the field of radiation, and the programs of the Radiation Bio-Effects Branch extend the scope of the Laboratory to include biological as well as physical aspects of radiation.

The Bio-Effects Branch performs the following functions: (1) plans and conducts research into the biological effects of ionizing and nonionizing radiation; (2) provides basic radiobiological information as needed in the Laboratory; (3) provides research data to assist in standard-setting and implementation of PL 90-602, the Radiation Control for Health and Safety Act of 1968; and (4) maintains animal colonies for related radiological health studies.

Nonionizing Radiation

During the past year a major portion of our efforts have been directed toward establishing a biological effects capability in the area of microwave radiation. A microwave irradiation facility was completed and thoroughly evaluated by our Electronic Products Branch. This facility has been tested so completely that we feel it is superior to most, in that we know what maximum limits of error exist under free field conditions.

This chamber has been used for preliminary studies in cytogenetics and in our chemical dosimetry program. These programs are designed to help determine more accurately the effects of microwave radiation on biological and chemical systems.

Ionizing Radiation

A portion of our research (see 4.1.2) in the field of ionizing radiation has been conducted under a Department of Defense contract. The purpose of the contract is to assess biological uptake of luminous compounds activated by radionuclides.

Tritium and ^{147}Pm are rapidly replacing the less desirable element radium as a source of activation energy for luminous compounds. These radionuclides are being assessed for their absorption into the tissues of test animals in order to determine the hazards which might be associated with their use.

During its first complete year of organization the Radiation Bio-Effects Branch realized certain basic accomplishments. Existing facilities were remodeled and adapted into useful tissue culture, media preparation and microscope rooms. Personnel from different backgrounds were brought together and have become a viable bio-effects research unit. Projects were developed which are contributing information to improve public health with respect to ionizing and nonionizing radiation. Contacts were made with the university community and with other radiological health laboratories to improve lines of communication.

For the next calendar year, major emphasis will be placed on studying the biological effects of microwave radiation. Several projects on acute microwave radiation exposure will be conducted as well as a study on the effects of chronic exposure. These studies have a planned duration of several years.

4.1 CYTOGENETICS SECTION — Mayme C. Colvin, Supervisor

4.1.1 CYTOGENETIC EFFECTS OF MICROWAVE RADIATION ON CHINESE HAMSTERS

This study is designed to determine cytogenetic effects of microwave radiation (frequency 2450 MHz) on kidney, lung and thyroid tissue of Chinese hamsters. It is the first phase of an extended study of biological effects of microwave radiation.

In preparation for the cytogenetics study, literature was retrieved and tissue culture techniques were developed for kidney, lung and thyroid tissues. Subsequent

to completion and evaluation of a microwave facility, preliminary data were collected on 51 irradiated animals to determine optimum exposure duration. Methods of handling the Chinese hamsters prior to irradiation procedures and a means for containing the animal during irradiation were also developed.

A two-minute exposure at a power density of 200 mW/cm^2 was found to be optimum (longer exposures caused death), and hamsters were handled in the following manner: Prior to irradiation, rectal temperatures were taken using a thermistor. The probe was inserted to a preset distance and temperature allowed to stabilize. The animal was then put into a section of nylon hose and both ends tied with nylon (Fig. 4.1). The hamster was secured to a styrofoam block and placed parallel to the polarization of the field directly beneath the center of the antenna (Fig. 4.2). After two minutes of irradiation, the test animal was removed, marked for identification and its rectal temperature taken as described above. Kidney, lung and thyroid tissues were removed and cultured for 72 hours. The cultures were then fixed, stained, and scored for aberrations.

Preliminary results from the cultured cells indicate a significantly higher percentage of aberrations in irradiated hamsters than in controls. Control cells had approximately one percent aberrations whereas cells from irradiated animals had 6 - 10 percent aberrations (Figs. 4.3 and 4.4). These results are not conclusive, as too few groups have been scored to yield significant data. However, the value of further definite work in this area has been demonstrated.

Two related studies planned for the near future are:

(1) A variation of the above experiment, in which animals will be irradiated for a preset time interval and the power density varied.

(2) A breeding study in which males and females will be irradiated for a prescribed time and their progeny observed. Number born alive, sex ratio and gross abnormalities will be recorded and selected offspring will be tested for chromosome abnormality.

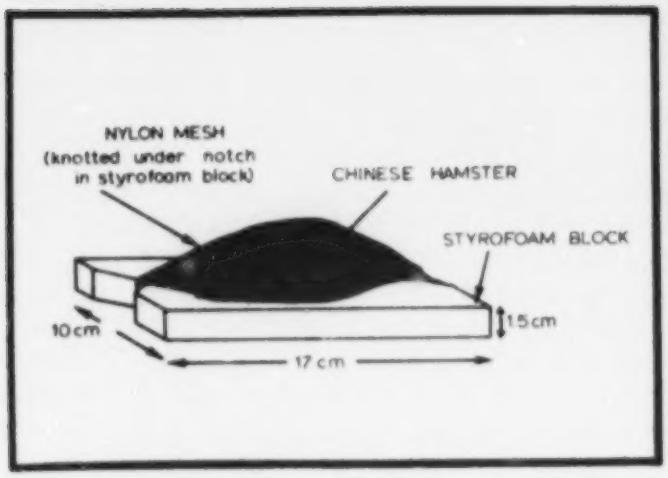

Figure 4.1 Restraining method for Chinese hamster

Figure 4.2 Placing hamster for irradiation

Figure 4.3 Normal chromosomes of Chinese hamster

Figure 4.4 Damaged chromosomes of Chinese hamster

4.1.2 CHROMOSOMAL CHANGES IN THE CHINESE HAMSTER FOLLOWING SKIN EXPOSURE TO TRITIATED LUMINOUS COMPOUNDS

Introduction. Work in this laboratory has demonstrated the absorption of tritium from tritiated luminous compounds through the skin. The cytological damage caused by tritiated thymidine (^{3}H TdR) has been investigated by a number of workers who have shown that the effects observed include chromosome abnormalities with levels of about 1 μCi/g body mass.[1,2] Early theoretical calculations[3,4] suggested that ^{3}H TdR should be considered more toxic to mammalian systems than tritiated water by several orders of magnitude.

This study investigates the absorption of tritium through the skin from an 8-hour exposure and the resulting alterations to the chromosomes of the Chinese hamster. Two compounds were selected for this study--one with a specific activity of 200 mCi/g and designated as MH (to denote manufacturer) and another designated RH with 20 mCi/g specific activity. Each hamster was exposed to 5-mg aliquots corresponding to either 1000 μCi or 100 μCi total activity.

Method. Thirty-day-old Chinese hamsters were acclimated in metabolic cages. One day prior to exposure the hair was clipped from the animal's back, using care not to break the skin. The following morning 5 mg of the luminous compound was weighed into an area 1 cm^2 on a piece of plastic wrap mounted on surgical tape (Fig. 4.5)

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(1) Bond, V. P., and L. E. Feinendegen, Health Physics 12,1007 (1966).

(2) Feinendegen, L. E., Tritium Labelled Molecules in Biology and Medicine. Academic Press (N.Y.) (1967)

(3) Guild, W. R., Science 128, 1308 (1958)

(4) Oliver, R., and L. G. Lajtha, Nature,London 185,91 (1960)

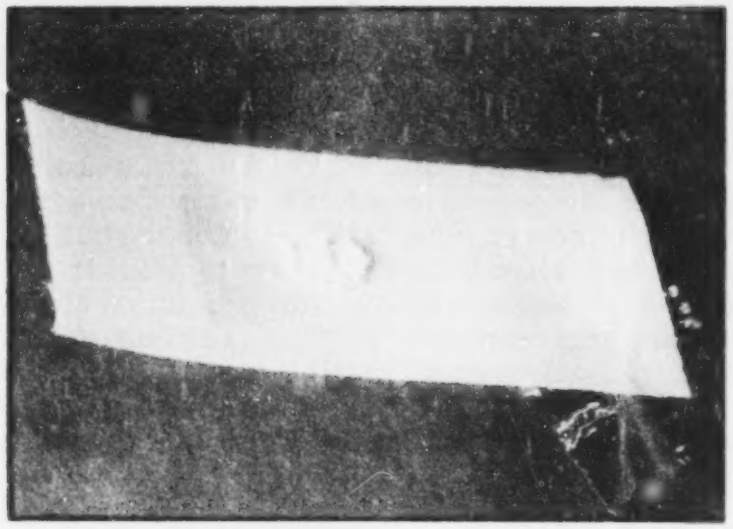
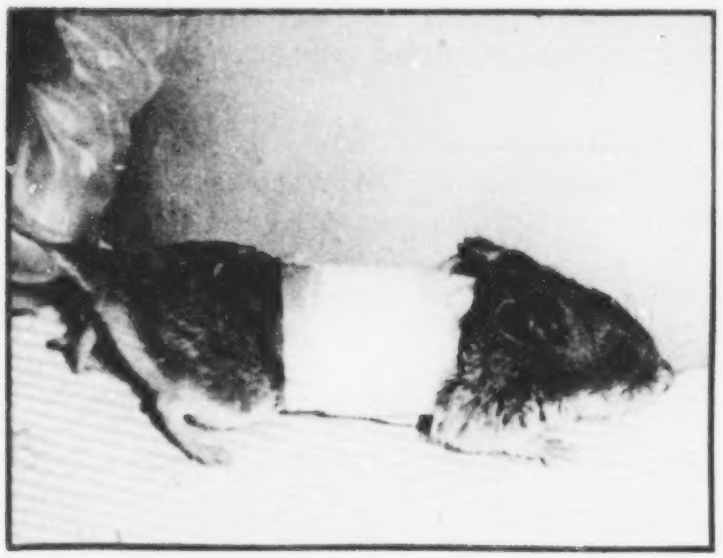


Figure 4.5 Luminous compound on tape

The bandage was carefully taped on the hamster's back by placing the animal upon the bandage with the compound facing the clipped area. An additional wider piece of tape was securely fastened around the animal's body as shown in Fig. 4.6. Eight hours later the bandages were removed and the remaining compound washed off carefully to avoid spreading it over a larger area.

Figure 4.6 Hamster exposure to luminous compound



Urine samples were collected every 24 hours to monitor for tritium absorption and excretion. The results obtained with a liquid scintillation counter were recorded as nanocuries of tritium per ml urine. Control animals were handled in the same manner.

Hamsters were scrificed for tissue culture at 7 and 30 days post exposure. Lung and kidney tissues were grown in Leighton tubes for chromosome studies. The cells were allowed to grow for 72 hours after which colcemide was added. This was followed in 3 to 4 hours with hypotonic treatment, fixation and staining.

Results and Discussion. The appearance of significant amounts of tritium in the urine of test animals was proof that skin absorption of tritium activity had occurred.

Slides of cells from treated and control animals were scanned under low power for metaphase cells. These cells were examined under phase oil immersion and classified as either aberrant or non-aberrant cells. A cell was considered non-aberrant if there was no evidence of chromosomal change. Although some of the cells were aneuploid, aneuploidy was not considered to be an aberration.

Metaphase cells containing chromosomes with structural abnormalities were counted as aberrant. These changes were classified as chromatid and isochromatid breaks, dicentrics, rings and exchanges. Chromosome or chromatid gaps were not scored as abnormalities, nor were fragments counted as chromosomes. Endoreduplications which occurred in 0.23 percent of total cells scored were classified as aberrant.

The majority of the aberrations were chromatid breaks while other aberrations occurred in the following decreasing order: isochromatid breaks, dicentrics, chromatid exchanges, endoreduplications and rings. This distribution held true for both compounds and at both post exposure periods. There was some increase in isochromatid breaks at 30 days, but they still did not outnumber the chromatid breaks. The results indicate that the most damage occurred during the G_2 phase of the cell cycle and

the slight increase in isochromatid breaks at 30 days could be due to second generation cells or to damage occurring during the G_1 phase.

In all animal groups the variation in damage to lung and kidney was less than one percent, therefore the data from the two tissues were combined.

There was only a slight difference in percent of aberrations between the two compounds, even though there was a 10-fold difference in dose. This possibility could be due to the fact that both doses represented maximum uptake. To verify this it will be necessary to expose another group of animals with a smaller dose.

Conclusions. The present study has investigated the possibility of chromosomal damage following skin absorption of tritium from luminous compounds, with these conclusions:

(1) Tritium was absorbed through the skin of Chinese hamsters;

(2) Chromosomal aberrations were produced at 7 and 30 days in both lung and kidney tissues to about equal degree; and

(3) The types of aberrations most often found indicated that damage occurred during the G_2 phase of the cell cycle.

4.2 CHEMICAL DOSIMETRY SECTION
Georgia L. Rehnberg, Supervisor

4.2.1 MICROWAVE CHEMICAL DOSIMETRY

The availability of a simple and accurate dosimeter to measure the exposure of individuals and population groups to microwave radiation is considered an essential aspect of the implementation of PL 90-602. This Section has attempted to develop a chemical dosimetry system by studying the effect of microwave radiation on properties of compounds.

In preparation for the studies, an attempt was made to determine the power output of the microwave oven (frequency 2450 MHz) and evaluate variations caused by changing positions of the sample in the oven. A 500-ml aliquot of distilled water was irradiated in 15 different positions on the oven tray (tray was placed at center oven). The power output, determined from the temperature rise in the known volume of water over a given time interval, ranged from 630 watts to 770 watts. An area right of center oven evidenced higher and more consistent power output. One liter of a 5 percent agar solution was poured on the oven tray, allowed to solidify, placed at the center of microwave oven and irradiated. Temperature determinations made immediately after removal of the agar from the oven showed "hot spots" at the right rear, right center, and right front of the oven. Upon repeating this procedure several times, the positions of these "hot spots" were verified. Placement of the sample to be exposed, therefore, was critical in order that it receive relatively consistent exposures.

Previous to 1970, studies on the effect of microwaves on optical activity indicated the presence of specific optical rotation changes as a result of microwave exposure. The total energy absorbed from the microwave radiation field in the microwave oven by the sucrose-polyvinyl-pyrrolidone-glycerin mixture was not known; therefore the functional relationship between changes in optical activity and absorbed microwave energy was not determined. Late in 1970 a calibrated microwave radiation facility was completed at the Laboratory and experiments were begun to study this relationship. No direct functional relation could be found.

During 1970 the effects of microwave radiation on certain enzyme and coenzyme systems were also studied. Enzymes investigated include sucrase, peroxidase, aldolase, alpha amylase, alcohol dehydrogenase, and catalase. The investigation of each enzyme was carried out in two phases. Initially enzymes were exposed to the high power density levels in the microwave oven. If the results of this exposure indicated that the enzyme might be sensitive to microwave radiation, it was then exposed to lower power density levels (200 mW/cm^2) in the anechoic chamber.

To compare the effects of heat and microwave radiation, samples identical to those irradiated in the oven and/or anechoic chamber, were heated in a mineral oil bath to temperatures equal to those reached as a result of microwave radiation. Enzymes were assayed before and after microwave exposure and thermal heating by procedures published by Worthington Biochemical Corporation. No indications were found which suggested that the enzymes studied were sensitive to microwave radiation.

The effects of microwave radiation on the viscosity of several polymers were studied. Polymers studied include Polyox WSRN-3000, Polyox WSR-205, polyvinyl-pyrrolidone (Plasdone C), Carborwax-6000, and Carborwax-400. The polymers were solubilized in water and/or glycerin and exposed to microwave radiation. Various dilutions of each polymer were used. The viscosity of each polymer was determined prior to and subsequent to microwave exposure. The effect of heat on each polymer was also evaluated. No changes were observed.

Some preliminary work was also done to evaluate the effect of microwaves on 2, 2-diphenyl-1-picryl-hydrazyl (DPPH), a stable free radical. The DPPH was dissolved in various organic solvents in order to determine one in which DPPH was most stable and less affected by sunlight. DPPH was most stable in chloroform, therefore this solvent was used. The solution was exposed to microwave radiation with no change noted. The absorbence of the DPPH was determined at 520 mμ before and after irradiation.

No positive results have been observed on the effects of nonionizing radiation on any of the compounds mentioned above.

4.3 ANIMAL CARE SECTION Blair F. Rehnberg, Supervisor

Assistance is rendered in designing experiments, while animals of a given age and sex are made available as required for all sections at SERHL requiring experimental animals.

Animal Stock. The bovine herd consists of three mature cows, one steer and two heifers. These animals have been used to determine the degree of transfer of ingested radionuclides to milk.

The Chinese hamster colony has increased to approximately 4000 animals (Fig. 4.7). Hamsters are used for cytogenetic studies following microwave exposure, or in cutaneous tritiated luminous compound absorption studies.

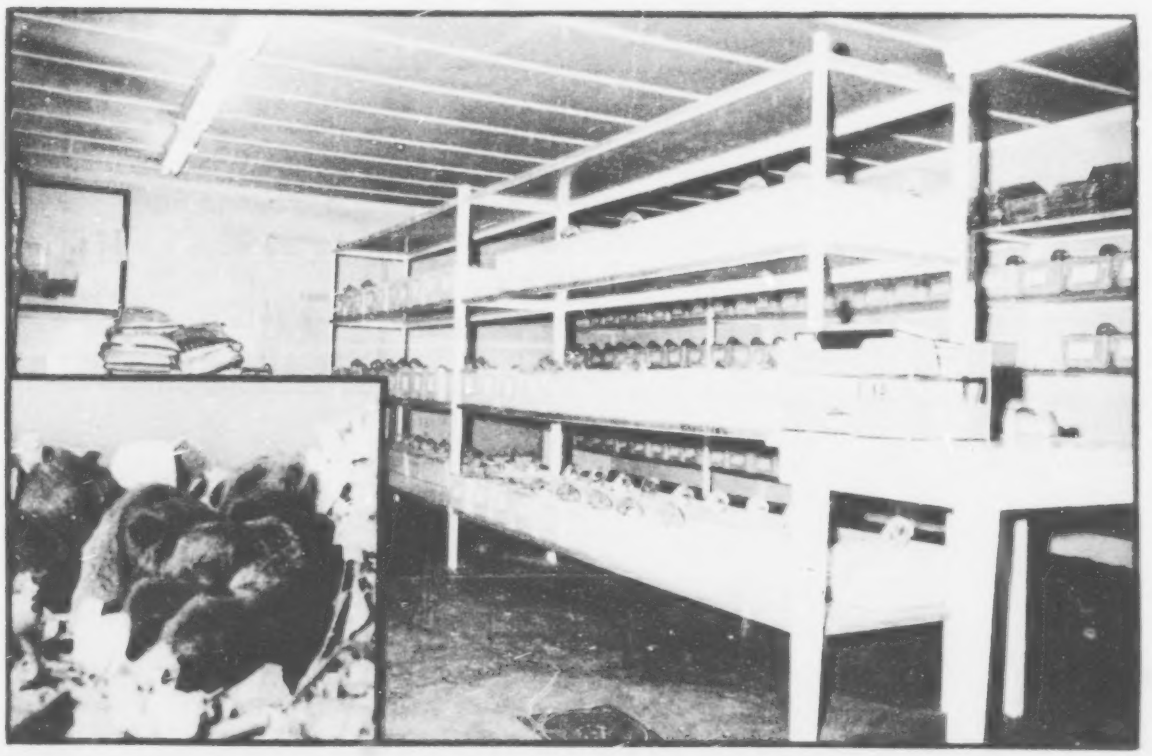


Figure 4.7 Hamster room and litter of Chinese hamsters

Twenty-two rats were used in tritiated luminous compound studies (percutaneous absorption) and 10 rats were used in ^{147}Pm luminous compound studies (subcutaneous injections of soluble ^{147}Pm).

Sixty-two cats have been purchased and a number of litters born. Twenty-seven cats were used to complete G.I. tract absorption studies of tritiated luminous compounds. Forty-five cats were fed luminous compounds activated by ^{147}Pm and 5 other cats were given subcutaneous injections of a soluble ^{147}Pm compound. At the end of the year there were 51 cats, including 28 kittens, in our cat colony.

The general health of the animals has been good due to proper diets and good sanitation.

Animals Used in Studies at the SERHL

Animal	Microwave	^{3}H	^{147}Pm	^{99}Mo	Technique Development
Rat	-	22	10	-	-
Cat	-	28	61	-	-
Hamster	84	68	-	-	751
Cow	-	-	-	1	-

4.4 LUMINOUS COMPOUND CONTRACT

4.4.1 ABSORPTION OF TRITIATED LUMINOUS COMPOUNDS IN CATS AND RATS

Tritium-activated luminous compounds are in relatively widespread use replacing the radium-activated compounds. More information is needed on the degree of G.I. tract and cutaneous absorption of tritium from tritiated luminous compounds since this radionuclide is a potential source of radiation exposure to industrial workers and the general public. This study was undertaken to determine the percent absorption of tritium from the luminous compound through the G.I. tract and through the intact skin. A comparison was made of tritiated luminous compounds from four different companies.

The cat was the animal of choice for the G.I. tract absorption study and the rat was the animal of choice for the percutaneous absorption study.

Methods. Four tritiated compounds were investigated and each compound was administered to 10 test animals in both the G.I. tract and the cutaneous uptake studies. Tritiated water was administered to 10 cats and 10 rats to serve as controls. The specific activities of the compounds were as follows: 3M Company, 200 mCi/g; Canrad Precision Company, 250 mCi/g; Radium Chemical Company, 250 mCi/g; and New England Nuclear, 600 mCi/g.

An area on the back of each rat was clipped and shaved one day prior to the cutaneous absorption study. The following day 10 mg of compound was spread over a 1 cm^2 area of plastic wrap attached to a length of surgical tape. The shaved area of the rat's back was then carefully placed on the compound. This bandage was held in place by a larger piece of adhesive tape placed over the surgical tape. Eight hours later the tapes were carefully removed and the area washed with warm water and soap to remove the adhering luminous compound. The shaved area was monitored with an ultraviolet light to ensure complete removal of the luminous compound during the washing procedure.

Total urine samples were collected every 12 hours from each rat for the first 3 days and then daily for 23-30 days. An aliquot of each urine sample was counted individually in a liquid scintillation counter. Clean separatory funnels were inserted when each urine sample was removed. Hexadecane was added to each collection vial prior to use to prevent evaporation of the urine.

The cats were acclimated to the metabolism cages 7-10 days prior to the experiment. Each of the four compounds was fed in 10-mg amounts to different groups of 10 cats. The luminous compound was placed in the center of a ball of cat food. The cats, having been without food overnight, ate the food in one bite. Daily total urine samples were collected from each cat for 43 to 73 days. An aliquot of each urine sample was counted in a liquid scintillation counter.

Results. Figures 4.8 and 4.9 depict daily urinary tritium activity (average of 10 animals in each group) divided by the amount of each compound administered after G.I. tract absorption in cats and cutaneous absorption in rats, respectively. All the luminous compound excretion curves show two components. A rapid component with a short effective half life is observed for the first 3-4 days which yields to a slower component with a longer effective half life. The slow component of the curve is similar in slope to that obtained from the animals administered tritiated water. A two-component excretion curve is not evident from the animals which received tritiated water.

These figures indicate that the least amount of tritium activity was absorbed (via skin and G.I. tract) from New England Nuclear Company and Radium Chemical Company compounds. The greatest amounts of tritium activity was absorbed from 3M Company's compound via these two routes, while Canrad Precision Company was intermediate in amount of tritium activity absorbed.

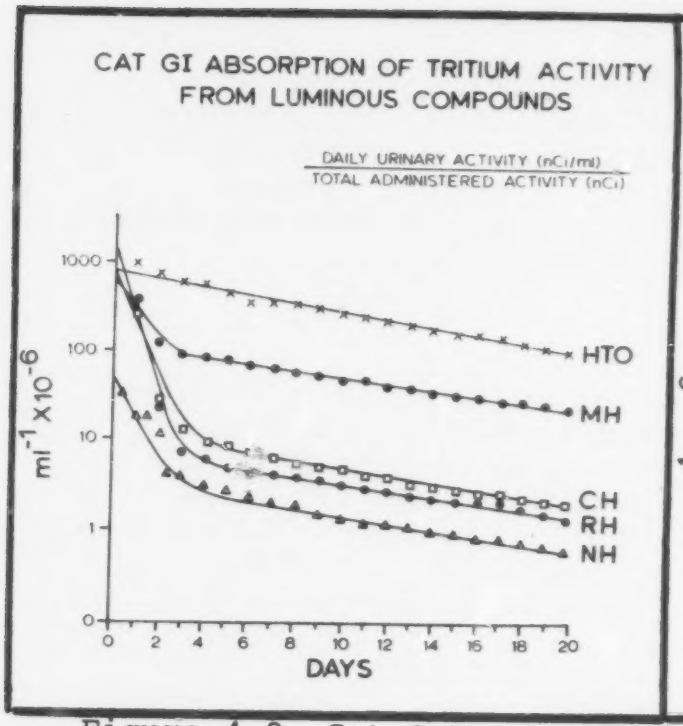


Figure 4.8 Cat G.I. absorption of tritium activity from luminous compounds

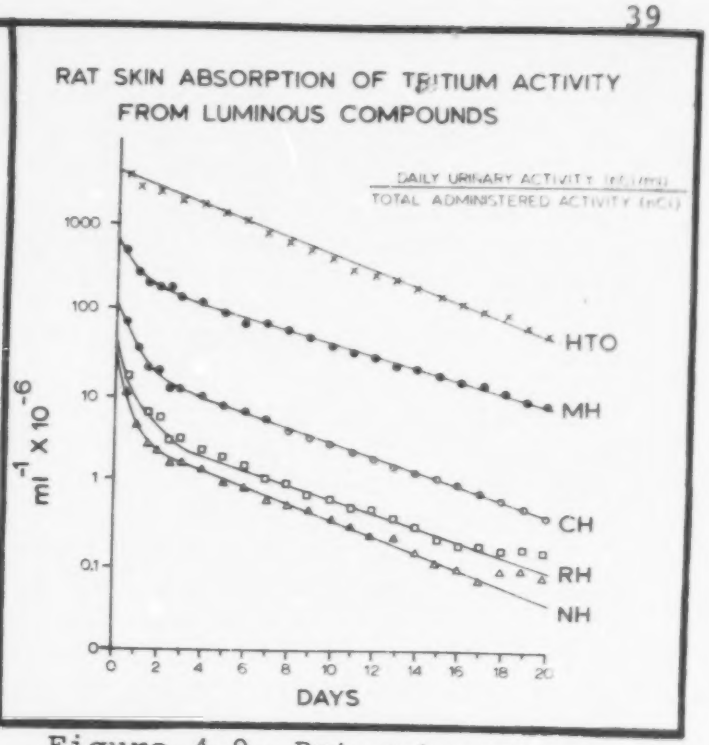


Figure 4.9 Rat cutaneous absorption of tritium activity from luminous compounds.

Conclusion. This work was performed to determine the percent absorption of tritium from four commercially available tritiated luminous compounds. The study disclosed that tritium was absorbed from the luminous compounds both through the skin and the G.I. tract. The percent absorption of the individual compounds via the cutaneous route varied from 0.10 percent to 8.83 percent and via the gastrointestinal route from 0.67 percent to 21.55 percent. The experiment was carried out as a worst case study since binder and adhesive (both normally present in the paint) were not added to the compound. These two ingredients could conceivably reduce the amount of tritium absorbed. In a plant producing these paints, however, the compounds would be present in the form studied.

The study indicates that there is a potential radiation hazard to personnel working with the luminous compounds both from G.I. tract absorption and cutaneous absorption. Care must be taken to prevent the ingestion or inhalation

of the compound. The hands and arms must be thoroughly cleaned and monitored after each day's work, and preferably monitored with an ultraviolet light for any remaining luminescence. It would also be advantageous to carry on a bioassay program in which urine samples from employees would be monitored on a monthly basis.

4.4.2 ^{147}PM-ACTIVATED COMPOUNDS

Promethium-147 is one of the compounds which is presently replacing radium as an energy source for luminous compounds. Experiments were undertaken to determine the percent absorption of some of these compounds into the G.I. tract of cats. Cats were randomly chosen for each experiment and were acclimated in metabolic cages for 10 days prior to dosing. A sufficient number of cats were acclimated so that unhealthy animals could be removed without interfering with the test. Four compounds were tested with 10 cats each and a fifth compound with 5 cats.

On the day of dosing, each cat was weighed and dosed with 100-125 μCi of ^{147}Pm-activated luminous compound. The cats were then placed in metabolic cages and urine and fecal samples collected daily for 21 days. These samples were analyzed for ^{147}Pm. At the end of the collection period, the animals were sacrificed. Kidney, liver, spleen, and long bone were removed and analyzed for ^{147}Pm content while the remainder of the carcass was prepared for analysis *in toto*.

The analysis procedure consisted of dry ashing tissue and carcass, solubilizing and separating the ^{147}Pm, and counting in a liquid scintillation counter. The data so collected will be used to determine the percent absorption of ^{147}Pm from the various luminous compounds.

This information, when combined with data on half-life and light output of the luminous materials, will be useful in evaluating the relative merits of the different radionuclides as energizers for luminous compounds.

5. APPLIED RADIATION TECHNOLOGY BRANCH

Neil F. Schneider, M.D., Acting Chief

Introduction

This program is responsible for radiological health aspects relative to radionuclide usage. Involved is the role of determining and investigating different problems confronting workers in various fields associated with radiation. Devices and techniques useful toward preventing unnecessary radiation exposure in radionuclide usage have been developed, such as an improved sealed source leak testing device and the SERHL program for storage of radium. A high degree of competency in radium handling has been developed. This has consisted of research relative to improving the radiation control of radium, its daughter products, and other radionuclides used by the medical profession, industry and others. Techniques to safely transport, store, utilize, test, and dispose of these materials have been investigated along with studies of the monitoring the decontamination of areas contaminated by these materials.

5.1 RADIUM REPOSITORY

The Branch provides a repository service for unwanted ^{226}Ra sources. Due to the lack of regulations requiring safe disposal of these sources, this service prevents potentially hazardous radium from being uncontrollably released. During 1970, 45 shipments comprising 4250 mg were received for storage, bringing the total to 5[illegible],080 mg of ^{226}Ra in the repository. The total quantity of radium stored at the SERHL over the past five years is shown in Fig. 5.1 and Table 5.1 indicates the types of sources received.

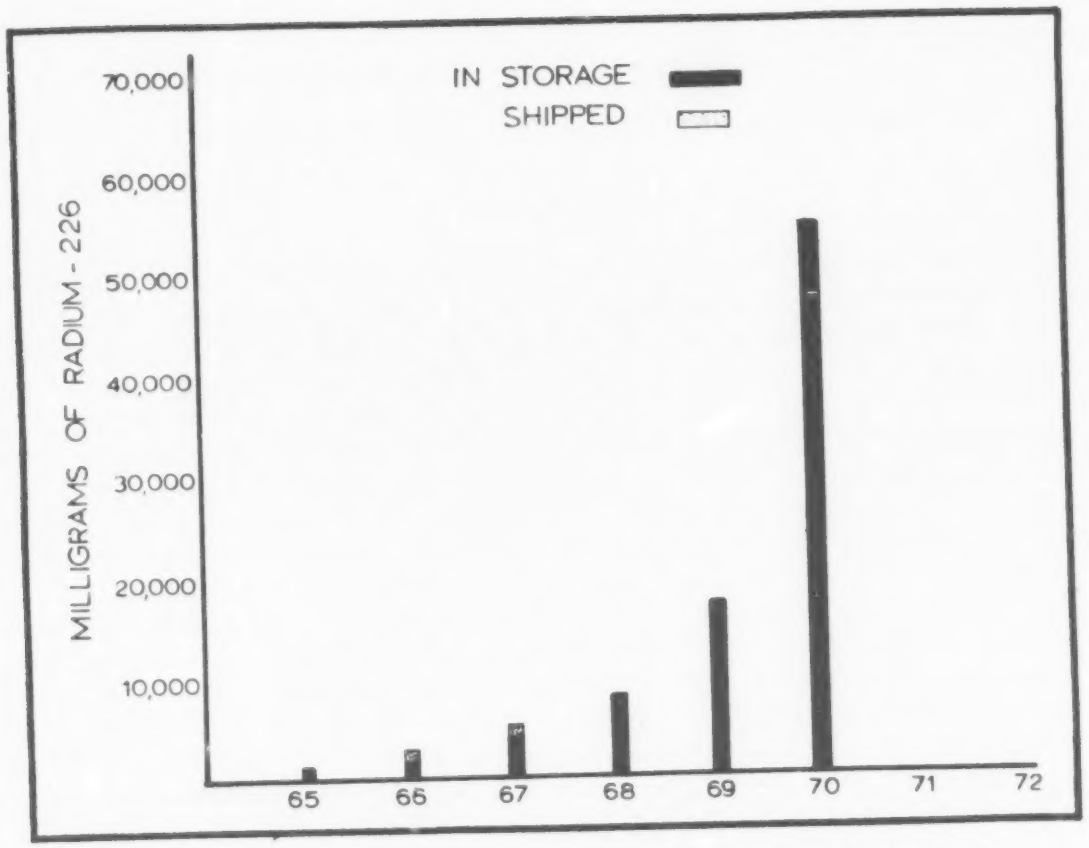


Figure 5.1 Inventory of radium in storage at SERHL

Table 5.1 Sources stored at SERHL

Table 5.1 Sources stored at SERHL

Types	Medical* No.	Medical* mg	Nonmedical** No.	Nonmedical** mg	Ra-Be No.	Ra-Be mg
Plaques	86	1078.970	5	51.904		
Tubes	115	1694.850	9	118.350	1	25.6
Needles	693	2895.460	59	97.520	1	500.0
Cells	186	834.910	26	29.160		
Capsules	1	50.000	16	20,790.640	35	24,124.21
Other:						
Nasopharyngeal	16	797.600				
Conical			1	243.000	1	514.0
Static Elim.			97	236.200		
Calib. Sticks			18	0.130		
Calib. Buttons			2	0.200		
Miscellaneous			441	2,663.340	2	61.59
Subtotal	1097	5656.940	674	24,230.444	40	25,225.400

Grand Total: 1811 sources; 56,807.634 mg

* Sources from medical facilities or from State health departments, except those identified as nonmedical.

** Sources identified as nonmedical.

5.2 PHOTOGRAPHIC LEAK TESTING DEVICE

One hazard associated with radium sealed sources (especially those with medical applications) is the possibility of leakage. Radium salts and first daughter product ^{222}Rn, a gas, can produce extremely hazardous contamination problems if released from a source thought to be sealed. For this reason, tests of radium sealed sources are necessary and are required by most States. This Laboratory has compared several commonly used leak testing techniques for their sensitivity and reliability. Results of this comparison are being prepared for publication. In addition a photographic technique for detecting radon released from leaking sources has been developed and tested. The leak-testing device has been modified to make it as sensitive as possible as well as simple to use with only minimal exposure to its operator. Fig. 5.2 shows the improved photographic leak test system; in Fig. 5.3 it is displayed as used to test sources while they are in a storage safe.

Figure 5.2 Source being placed in chamber of photographic leak test system. Leaking radon passes thru tube to activate phosphor, producing image on film.

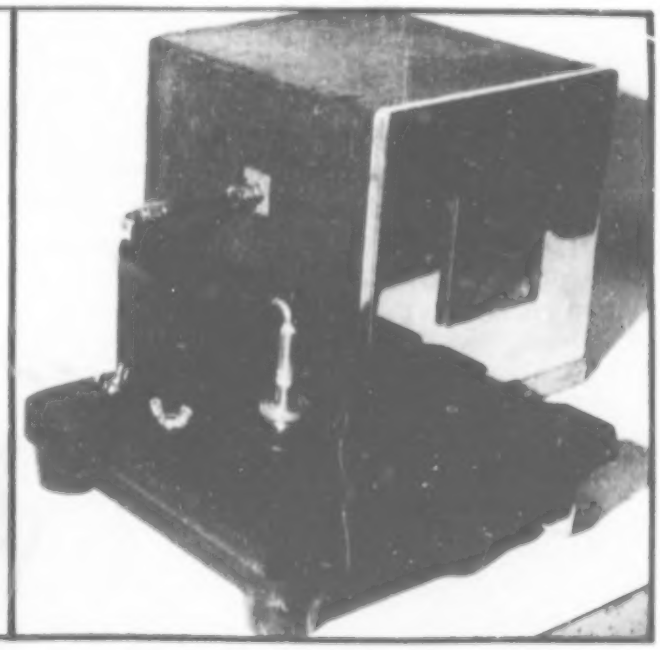


Figure 5.3 Photographic leak test system connected to radium needle storage safe.

This device has been demonstrated and left for field testing in six different medical facilities. Demonstrations of the leak tester have been made during 1970 at the annual Radiological Society of North America Meeting and two regional meetings of radiological health personnel. A paper entitled "Improved Photographic Leak Test System for Sealed Sources of Radium-226" has been published in the American Journal of Roentgenology 112(4):788-91 (1971). Present investigations with the leak tester include development of a reliable calibration in terms of radon activity and utilization as a storage area monitor for radon release.

5.3 SEALED SOURCE TESTING

Since radium is most hazardous when released from a source it is necessary to know how much stress a sealed source can take. This will be determined by subjecting representative sealed sources with small quantities of radium to different tests that will duplicate possible stresses applied to them in practice. These tests will include: ultrasonic cleaning, positive and negative pressure, high and low temperature, impact and bending. In order to carry out these tests a sealed source testing facility has been built. Development of this facility has included design and construction of a primary containment structure that provides protection to the operator and prevents uncontrolled escape of radium and radon to the environment. Shown in Figures 5.4 and 5.5 the test cell with two remote manipulating arms is air-tight and is shielded by four inches of lead. The air inside this system can be pumped out through combinations of absolute and charcoal filters to prevent releases of radioactive gases to the atmosphere. Housed within this chamber are:

a) A tensile strength and compression testing instrument for measuring breaking and bending loads of test sources.

b) An impact system for dropping weights onto sources.

c) Hot and cold temperature test systems.

d) Positive and negative pressure systems.

All the above tests are carried out on sources that are contained in small "mini" chambers. Testing procedures have been designed and equipment built to minimize contamination within the primary containment cell.

Figure 5.4 Sealed source test cell, outside view

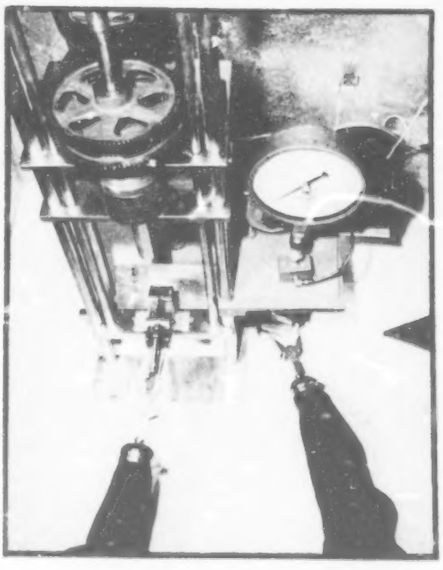


Figure 5.5 Sealed source test cell, inside view

5.4 RADON MONITOR

Because ^{222}Rn is an inert gas it can diffuse through air, thus spreading its radiations and contamination to areas considered free of radioactive material. A radon monitor has been developed that detects the presence of the radioactive gas by photographic means (similar in principle to the photographic radium leak tester) and can be used to measure its concentration. The device has been tested under laboratory conditions and found to detect ^{222}Rn levels down to 200 pCi/l. Additional testing at lower levels and under environmental conditions is being conducted in several residences known to have radon-emanating ore present. It is planned that the photographic system will provide a simple and inexpensive, but reliable, means for measuring radon exposure.

5.5 POWDER FUSION

One reason leaking radium sources cause major contamination problems is that radium salts are finely divided powders that can spread very easily. Therefore, investigations on fusing the powder inside a source have been carried out. Experimental methods for doing this have not been successful due to the high melting point of radium compounds and its similarity to the melting point of platinum-iridium alloy that is used for source encapsulation. Addition of a fusing compound with a lower melting point is being considered as a possible means of overcoming this difficulty.

6. ELECTRONIC PRODUCTS BRANCH

Charles R. Phillips, Chief

The Electronic Products Branch is responsible for activities in three areas:

(1) Research and development in the detection, measurement and evaluation of microwave radiation,

(2) Research and development of instrumentation and techniques for measurement and interpretation of ionizing radiation and radionuclide levels, and

(3) Maintenance of electronic instrumentation for the Laboratory.

Much work, especially in the latter two areas, is generated in response to needs expressed by other components of the Laboratory. Self-generated projects comprise the remainder of the work of this Branch.

A major research effort was the construction and calibration of a microwave irradiation facility for use in the SERHL's cytogenetic studies. Techniques to detect leakage from microwave ovens were evaluated with Polaroid film determined as a feasible indicator. Development continued on the tritium air and water monitor, while research began on a ^{147}Pm whole-body ccunter.

These and other projects carried out during calendar year 1970 are discussed.

6.1 MICROWAVE SECTION

Since the enactment of PL 90-602 there has been increased interest in the exposure of individuals to non-ionizing (e.g., microwave) radiation. The Microwave Section is responsible for applied research concerning measurement of microwave radiation levels, support of experimentation regarding possible biological effects of

microwave radiation, analysis of potential hazards of environmental microwave sources, and consultation with State, county, and local health officials regarding possible radio-frequency hazards. Projects performed by this section include the measurement of microwave oven leakage using Polaroid film; design, construction and calibration of a microwave irradiation facility; hazard evaluation of marine radar; and evaluation of fluorescent light bulbs as microwave oven safety interlocks. A description of each project follows:

Microwave Irradiation Facility. In order to perform studies on the biological effects of microwaves, a facility was constructed to vary the exposure field for these studies. The facility, which consists of an anechoic chamber and microwave generator (Fig. 6.1), was designed and constructed

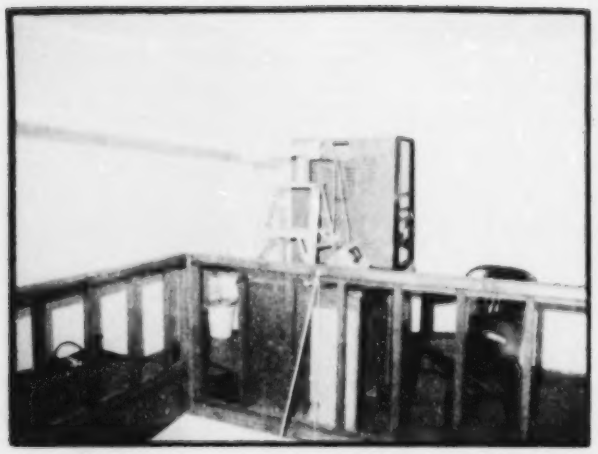


Figure 6.1A Microwave generator and waveguide

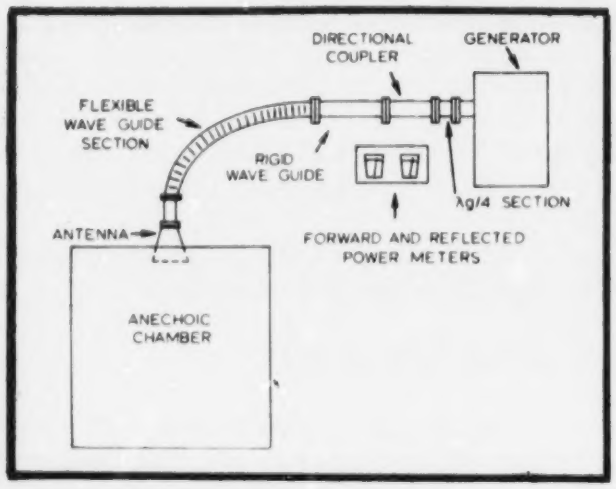


Figure 6.1B Schematic of microwave generator and waveguide

at the SERHL to irradiate small experimental animals at accurately specified continuous wave (CW) power densities. Accurate specification of these power densities required that the microwave generator be calibrated to determine the power delivered to the irradiating antenna. A report is in progress concerning the calibration of this high power microwave generator. The power density is variable up to 200 mW/cm^2 for single animal (small area) irradiation and up to approximately 30 mW/cm^2 for several animals (large area). The Chinese hamster is the initial animal for the study.

The facility operates in the 2450 MHz industrial-scientific-medical (ISM) band. Linear and circular polarization is available utilizing a variable polarization antenna with accurately determined gain characteristics. The anechoic chamber, which is a cube with 10-foot sides, is capable of simulating reflectionless free-space irradiation conditions (nominal -40 dB) within the irradiation region.

6.1.1 POLAROID MICROWAVE LEAKAGE MEASUREMENT

Because of the current interest in accurate and inexpensive methods for measuring microwave radiation, particularly the leakage radiation from microwave ovens, the possible use of Polaroid film was investigated. It was found that Polaroid Type 58 color film packets provide an inexpensive means to visually indicate microwave fields with power densities greater than 5 mW/cm^2. This power density is the value set by PL 90-602 for microwave ovens following purchase by the consumer. It is measured at 5 cm from any readily accessible surface on the oven. In our studies the power density values were measured at 5 cm from the oven door with a Narda 8100 meter and appropriate probe. Since the rate of development of the film is temperature sensitive, the localized heating resulting from microwave exposure causes a selective increase in development rate in these areas. This increase in development rate results in a darkening of the film in the heated areas and the formation of an image corresponding to the intensity of the electromagnetic field. Film exposed to <5 mW/cm^2 can be visually differentiated from those exposed to 5 mW/cm^2 or more.

The development of the film was initiated by using a #545 Polaroid Land film holder. After 5 seconds of development time, the film packet was placed in the microwave field and exposed for 25 seconds. The development was stopped 10 seconds later by removing the photograph from the developing jacket. Use of these times yielded a photograph with maximum darkening of the film. This concept has proven feasible as a rapid and inexpensive method of determining leakage from a microwave oven. Further work remains to evaluate fully the parameters involved.

6.1.2 HAZARD EVALUATION OF MARINE RADAR ON PLEASURE CRAFT

Due to growing evidence that radar workers are more likely to have cataracts formed in their eyes than persons unexposed to microwave radiation, the potential hazard of marine radar units is being evaluated. These radar units are frequently mounted in areas where persons can easily be exposed to the primary beam of radiation. For example, units are commonly mounted so the helmsman's head is within three to six feet of the antenna and the primary beam of radiation is frequently at eye level (Fig. 6.2).

Figure 6.2 Marine radar in use illustrating possible microwave exposure to personnel on board.

Conditions such as these emphasize the need for investigation of the possible hazards of operation of marine radar units.

The purpose of this study is to examine microwave power densities associated with the operation of marine radar units used on small pleasure-type craft. Data have been cataloged on 30 different units with peak power of 25 kW or less. Using the parameters furnished by the manufacturers, theoretical predictions of both maximum peak and maximum power density average values have been made. From these theoretical calculations it appears that average power densities in excess of 10 mW/cm^2 (current standard of USASI for exposure times $\geq$6 minutes) may exist in regions near the antenna. These predictions will be checked by field measurements on a sample of radar units on crafts. This project will be completed by the end of FY-71.

6.1.3 FLUORESCENT LIGHT BULBS AS MICROWAVE OVEN INTERLOCKS

Presently there is no active interlock in any microwave oven which will stop the generation of microwave radiation when the actual radiation leakage outside the oven door exceeds a preset power density level. The purpose of this project was to study the feasibility of using fluorescent light bulbs for interlocks as an integral part of microwave ovens using the property of the bulb's ignition in a microwave field.

Procedure. Fluorescent bulbs (4, 6, and 8W) were placed in stainless steel brackets above the door crack. The brackets were used to enhance the bulb's light emission. Using brackets which held the bulbs 1, 1 1/4, and 1 1/2 inches from the oven, an attempt was made to determine if a distance could be found which would ignite the bulbs at leakage levels of approximately 5 mW/cm^2 but not at lesser leakage levels. Such a distance was not determinable from the experiments performed due to the factors explained below.

The results of this study indicate that fluorescent bulbs can be used in a circuit for microwave interlock only with a greater effort than would be economically feasible. The bulbs do not have a uniform ignition level and would require critical individual spacing to ignite at a predetermined leakage level. No further investigation on this project is anticipated at this time.

6.2 PRODUCT TESTING SECTION

During 1970 the Bureau of Radiological Health conducted a national survey of microwave ovens to determine the condition and leakage levels of ovens in use by the public. Data were collected on oven condition, energy leakage levels and use parameters. Based on national survey results, manufacturers of ovens which leaked in excess of the industry standard were required to initiate correction programs so their respective ovens would meet this standard (10 mW/cm^2).

In support of the national survey the SERHL participated in the survey of approximately 200 microwave ovens in Alabama, Georgia, Texas, and Tennessee. Of this number, 188 were located in Alabama. When ovens were found to be leaking slightly above the industry design specification of 10 mW/cm^2 at 2 inches, owners were advised to obtain repair services as soon as possible. When an oven was found to be leaking far above the design limit, the owner was advised to discontinue use of the oven and obtain repair service before resuming use.

When possible, operators and owners were advised of the necessity of maintaining clean door seals to prevent microwave energy leakage and of the desirability of a clean oven. The pamphlet "Facts About Microwave Oven Radiation" was distributed to some of these owners and operators contacted.

6.3 INSTRUMENTATION SECTION

Projects conducted within this Section are divided among three areas: research and development, maintenance, and support. Research projects usually involve the

development of ionizing radiation instrumentation for specialized applications. The maintenance aspect includes repair service on various electronic instrumentation used throughout the Laboratory and all the equipment within this section. Aid is also rendered to the Electronic Maintenance Section as requested. The support provided to other branches of the Laboratory usually includes experiments which can be handled only in this section's laboratory, and construction of physical and electronic devices.

Of various projects undertaken, two received top priority. These were the continued development of a tritium monitor and a ^{147}Pm whole-body counter.

Construction of an air and water monitor for tritium had begun the previous year. It employed coincidence photomultiplier tube detection techniques used in liquid scintillation counting. This method theoretically eliminated undesired characteristics of commercially available ionization chamber monitors. A detector employing thin plastic scintillator sheets and anthracene-coated rods proved to be very encouraging. However, the anthracene tended to deteriorate with time and efforts were concentrated on the plastic scintillator. Thin acrylic plastic sheets covered by a film of plastic scintillator proved to lose little sensitivity for the tritium beta when compared to the solid scintillator sheet but exhibited a much lower sensitivity to background gamma. This prompted further studies toward developing a film coating technique which would yield a very high sensitivity and would economize on construction of the detector, thus making commercial manufacture of such a monitor feasible.

The lack of a practical and accurate means for determining whole-body concentrations of ^{147}Pm in people with possible body burdens of the isotope led to initiation of the promethium whole-body counter project. The method employed involved the use of a FIDLER probe to detect Bremsstrahlung rays emanating from the human liver which

absorbs a high percentage of all promethium ingested. Water phantoms were constructed and the sensitivity of the instrument was found to be adequate to warrant further development of the project.

Plans toward completion of the project include three main phases: (1) The system will be quantitized using lab phantoms. (2) Tests on humans will be conducted and results compared to data obtained using present methods. (3) Possible minor modifications in data analysis will be made, following which the system should become an accurate and practical device for determining body burdens of promethium.

Major support projects consisted of construction and testing of a solid-state alpha counter, zinc sulfide coated PM tube alpha counter, and an electrolysis system. The alpha counters were designed for low level counting which demanded a low background sensitivity. Both functioned well, but for economic reasons the PM tube version was preferred to the solid state. The electrolysis system was constructed to provide the laboratory with facilities for the enrichment of water samples containing trace amounts of tritium.

Minor support projects included accumulation of instrumentation for constructing a specialized TLD reader, technological aid to the microwave section, and writing specifications for a Ge(Li) detector system to be used by the Nuclear Facilities Branch.

7. TRAINING BRANCH

Robert S. Callis, Chief

The Training Branch at SERHL has two primary functions:

(1) the development and presentation of short courses in the various aspects of radiological health, and

(2) the planning and coordination of special training activities, such as on-the-job or bench training at SERHL, guest lectures, and seminars.

The training staff at SERHL consists of four full-time instructors, whose education and experience encompass many phases of radiological health. The training staff is responsible for gathering and evaluating current developments in the radiological health field for inclusion in formal course presentations, in addition to the evaluation and preparation of supplementary visual aids and laboratory exercises. The training staff is supported by other professional staff members of the Laboratory who lecture in special subject areas.

7.1 DEVELOPMENT AND PRESENTATION OF SHORT COURSES

Course Development. Two new training courses were developed and presented:

(a) "Introduction to Radiological Health for High School Science Teachers" was presented for the first time in Birmingham, Alabama, to 48 high school science teachers. The course is designed to give high school science teachers a basic knowledge of radiation protection as related to radioactive isotopes and electronic product radiation.

(b) "Microwave Instrumentation and Survey Techniques" was presented for the first time March 16-19, 1970. Twenty-three students

representing eight States, attended this course which was designed to provide a basic knowledge of microwave production, survey instrumentation, and techniques involved in making microwave surveys.

In addition to the new courses, considerable revision work was performed on the following courses: "Management of Radiation Accidents," "Basic Radiological Health," and "Occupational Radiation Protection."

Course Presentations. The SERHL Training Branch presented 120 days of technical training to 391 persons. Seventy-four days of this training were presented at SERHL; the remainder was at field locations in Alabama, Florida, Mississippi, South Carolina, and Texas. Table 7.1 summarizes the courses presented during 1970.

Table 7.1 Courses presented during 1970

Course Title	Length of Course	Number of Times Presented	Total Days Presented	Number of Students	Man-Days of Training
Basic Radiological Health	10	3	30	47	470
Occupational Radiation Protection	10	2	20	25	250
Introduction to Radiological Health for High School Science Teachers	3	1	3	48	144
Introduction to Medical X-Ray Protection	2	2	4	138	276
Training for Instructors of X-Ray Protection	5	2	10	14	70
Radiological Health for X-Ray Technicians	2	5	10	64	128
Medical X-Ray Protection	10	1	10	8	80
Microwave Instrumentation and Survey Techniques	4	1	4	23	92
Radionuclide Analysis by Gamma Spectroscopy	10	1	10	13	130
Introduction to Occupational Radiation Protection	10	1	10	5	50
Advanced Radiological Health for X-Ray Technicians	10	1	10	6	60
TOTAL		20	121	391	1,750

SERHL training courses reach students having widely divergent geographical and educational backgrounds, as indicated by Figures 7.1 and 7.2 below.

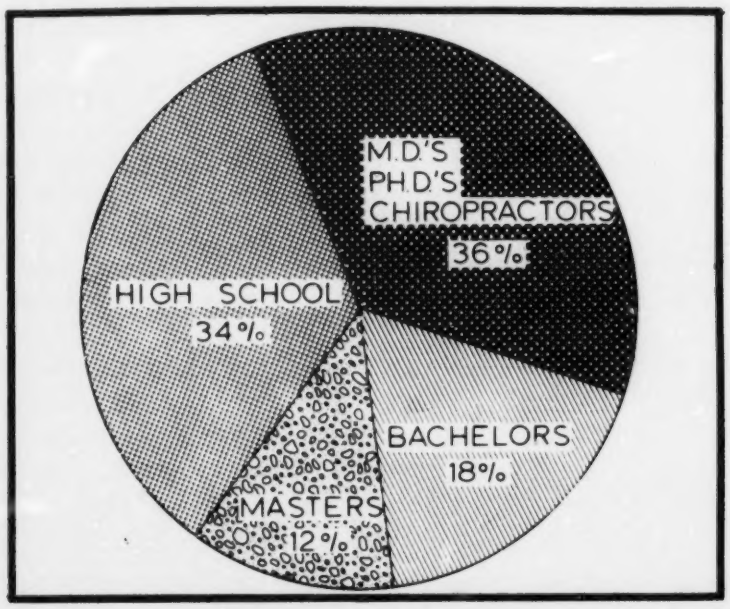


Figure 7.1 Educational level of attendees by percentage

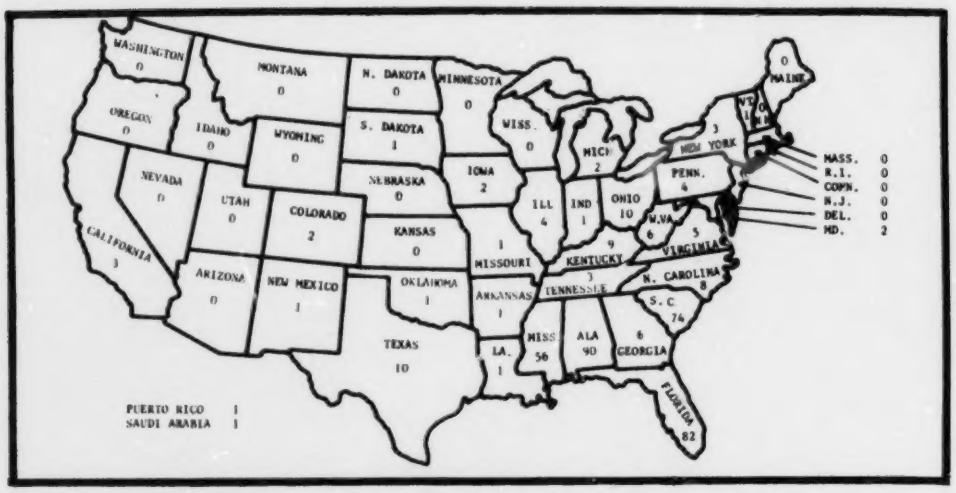


Figure 7.2 Enrollment by State in SERHL training courses

7.2 SPECIAL TRAINING ACTIVITIES

On-the-Job Training. Through the planning and coordination of the Training Branch, the SERHL has provided on-the-job training in several areas. Participants in this type of training include personnel from State health departments, the military, and various other governmental agencies.

Lectures and Seminars. Special lectures on radiological health topics have been presented to several groups by the training staff. These groups include junior and senior high schools in the surrounding area and a Statewide meeting of the Alabama Civil Defense Agency.

Other Activities. In an effort to reach more x-ray technicians, the course "Introduction to Radiological Health for X-Ray Technicians" was condensed and put on video tape. Copies of this video tape will be made available to schools of x-ray technology, hospitals, and various other groups.

8. OFFICE OF QUALITY CONTROL

D. Gene Easterly, Chief

Assuring the precision and accuracy of SERHL analytical procedures is the primary purpose of the Analytical Quality Control Program, while also providing other laboratories with consultation to help in verifying the quality of their analytical data. The Program at SERHL cooperates with the Analytical Quality Control Services (AQCS) of the Bureau of Radiological Health, which is administered from the Northeastern Radiological Health Laboratory at Winchester, Massachusetts.

A basic function of the SERHL Program is to record the daily count rate of a standard in each instrument to illustrate trends or major malfunctions of instruments. In addition, duplicate analyses are performed on 20 percent of routine surveillance samples to confirm precision of the analyses. The accuracy of analyses is tested by the use of weekly milk references (spiked simulated milk samples), monthly AQCS cross-check samples, and bimonthly AQCS food and water cross-check samples.

Precision and accuracy of other laboratories are assessed by comparing data from the analysis of split Pasteurized Milk Network (PMN) samples. SERHL analytical results of a milk sample portion are compared to those obtained by a State laboratory on a portion of the same sample. The accuracy of this comparison is supported by the analysis of spiked samples by several State laboratories and the SERHL.

In an effort to assist State, university and community laboratories, SERHL analyzes samples analyzed at other laboratories to complement their quality control. In addition, a cooperative program of testing split samples is being carried on with government laboratories of Panama Canal Zone, Puerto Rico, Okinawa and TVA.

8.1 QUALITY CONTROL PROGRAM FOR SERHL

This Office submitted 91 milk and 61 food samples to Analytical Services Section for duplicate analyses by gamma spectroscopy. These results are tabulated in Table 8.1. Results of analyses performed on milk and food quality control samples are listed in Table 8.2.

Table 8.1. Duplicate analyses by gamma spectroscopy

Nuclide	$\leq\bar{R} + \sigma_R$	$\leq\bar{R} + 2\sigma_R$	$\leq\bar{R} + 3\sigma_R$
Milk samples			
^{131}I	84 (92%)	91 (100%)	
^{140}Ba	73 (80%)	90 (99%)	91 (100%)
^{137}Cs	79 (87%)	89 (98%)	91 (100%)
K	84 (92%)	89 (98%)	91 (100%)
Food samples			
^{131}I	53 (87%)	61 (100%)	
^{140}Ba	61 (100%)		
^{137}Cs	57 (93%)	59 (97%)	61 (100%)
K	58 (95%)	61 (100%)	

Table 8.2. Analytical results on quality control samples

Nuclide	$\leq\bar{R} + \sigma_R$	$\leq\bar{R} + 2\sigma_R$	$\leq\bar{R} + 3\sigma_R$
Milk chemistry			
Sr	30 (97%)	31 (100%)	
Sr	20 (94%)	31 (100%)	
Food chemistry			
^{226}Ra	21 (95%)	21 (95%)	22 (100%)
^{90}Sr	29 (94%)	31 (100%)	
Ca	31 (100%)		

Results shown in the above tables meet the requirements of internal reproducibility prescribed by AQCS (Table 8.3). Simulated milk samples were counted weekly and results were compared to the known concentrations (Table 8.4).

Table 8.3. AQCS requirements of internal reproducibility

Nuclide	Level	Standard Deviation
^{131}I, ^{140}Ba, ^{137}Cs, ^{90}Sr	≤100 pCi/l or kg	5 pCi/l or kg
	>100 pCi/l or kg	5%
^{90}Sr	≤ 30 pCi/l or kg	1.5 pCi/l or kg
	> 30 pCi/l or kg	5%
Stable K	All levels	0.06 gm/l or kg
Stable Ca	All levels	0.02 gm/l or kg
^{226}Ra	All levels	0.2 pCi/kg

Table 8.4. Weekly milk reference - gamma analysis

Nuclide	≤Known ± σ_m	≤Known ± $2\sigma_m$	≤Known ± $3\sigma_m$
^{131}I	33 (73%)	45 (100%)	
^{140}Ba	37 (82%)	42 (93%)	44 (98%)
^{137}Cs	22 (49%)	40 (89%)	45 (100%)
K	31 (69%)	40 (89%)	44 (98%)

8.2 ADDITIONAL PROGRAMS AND ACTIVITIES

Data were exchanged with the following States in connection with the SERHL-State milk quality control project.

Florida State Board of Health	30 samples
Tennessee Department of Health	41 samples

The gamma spectrometers were restandardized. Sources were prepared for use in standardizing the alpha spectrometers.

The SERHL participated in a technical experiment conducted by AOCS entitled "Interlaboratory Study of ^{131}I, ^{137}Cs, ^{140}Ba, ^{89}Sr, and ^{90}Sr Measurements in Milk." Results obtained by SERHL in this experiment were statistically satisfactory. The SERHL is participating in the technical experiments "Rapid Field Method for Determination of Radiostrontium in Milk," and "Tritium Intercomparison."

9. OFFICE OF RADIOLOGICAL HEALTH AND OFF-SITE SURVEILLANCE

Norman E. Childs, Chief

As part of its responsibility concerning public health, the SERHL provides off-site environmental surveillance in support of the AEC underground testing program in Mississippi and the NASA Apollo programs at Cape Kennedy. Activities in the latter program are described in this report under Office of Aerospace Liaison.

9.1 HUMID WATER EVENT

Off-site coverage was provided by the U.S.Public Health Service (PHS) for the Humid Water Event, an underground chemical explosion detonated at 1245 hours CST on April 19, 1970, near Hattiesburg, Mississippi. It was the second Vela Uniform test of the Miracle Play Series. The Miracle Play Series was sponsored by the Advanced Research Projects Agency of the Department of Defense. The purposes of the project were a) simulation of blast effects of underground nuclear explosions by detonable gas explosions, and b) measurement of the reduction in seismic decoupling of gas explosions in an overdriven cavity.(1) Vela Uniform was a seismic research program designed to improve the United States' capability to detect, identify, and locate underground nuclear detonations.

The Humid Water Event had a design yield of 315 tons (explosive force of the corresponding tonnage of TNT). The detonable mixture consisted of a 1.6:1 ratio of oxygen to methane. Although Humid Water was not a nuclear detonation, in accordance with a Memorandum of Understanding with the Atomic Energy Commission, the PHS was responsible for the off-site radiological safety since the mixture was detonated in an underground cavity previously created by the Salmon Event, a nuclear detonation conducted in 1964. This event took place 2700 feet underground in a salt formation known as the Tatum Salt Dome, located 19 air

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(1) NVO-64, Planning Directive, TC/DASA, Miracle Play Series, Feb. 1970

miles southwest of Hattiesburg, Mississippi. The fission yield of the Salmon Event was 5.3±0.5 kt, and the consequent cavity was 110 feet in diameter. A second nuclear detonation, the Sterling Event, was fired in this cavity in 1966, and had a fission yield of 0.38 kt.[1] The Diode Tube Event, the first Vela Uniform chemical detonation test of the Miracle Play Series, was fired in the cavity in 1969. The yield of this test was approximately 100 tons. The potential hazards of the event consisted of toxic gases (carbon monoxide, hydrogen sulfide, and carbon dioxide) and radionuclides (^{3}H, ^{125}Sb, and ^{137}Cs).

The Humid Water Event was prematurely detonated at approximately 1245 hours CST, two days prior to the official scheduled shot time. The premature detonation was attributed to lightning striking the firing cable. PHS personnel had been on standby since the introduction of the detonable mixture into the detonation cavity and, therefore, were ready to respond to such an unexpected development. No radiation or toxic gases were detected following the event. Bleed-down of the cavity gases began on May 2, 1970. Environmental surveillance detected no radioactivity above background during the various phases of bleed-down and off-site coverage was terminated on June 2, 1970.

Although the odor of H_2S was apparent from time to time during bleed-down operations, the levels were not detectable by detection instruments used and were far below any present health guidelines. Air-borne concentrations of CO and CO_2 were also below detectable levels. Off-site residents were confident regarding the competence of the PHS personnel and expressed minimal concern regarding the H_2S odor or the shot in general.

10. OFFICE OF AEROSPACE LIAISON

Ronald L. Shearin, Chief

Cooperative support activities with the NASA-Kennedy Space Center and the Air Force Eastern Test Range (AFETR) continued during 1970 through the Office of Aerospace Liaison. Direct support to the launch operations of Apollo 13 was provided by an off-site contingency monitoring operation implemented during the final countdown stage of the launch. This support was requested due to the large inventory of ^{238}Pu carried in the radioisotopic thermoelectric generator on the Lunar Exploration Module. The contingency operation included seven 2-man teams with monitoring instrumentation and radio-equipped vehicles, and a command staff of three men directing the teams and performing interagency coordination. Mr. John C. Villforth served as Operations Director, Mr. Charles Phillips as Operations Officer, and Mr. Ronald Shearin as Liaison Officer.

During this operation all radiological assessment units were managed through the PHS radio network and the Liaison Officer served as network communicator. Consolidation of communications in this manner enhanced the effectiveness of the total radiological contingency operations.

With a reduction in activity within the AFETR Bioastronautics Directorate and subsequent reassignment of this activity to the Patrick Air Force Base Hospital, the on- and off-site environmental monitoring survey programs were terminated. Evaluation of the accumulated data from this study determined that sufficient information had been acquired to meet the objectives of the program. Pending plutonium analyses of several soil samples from this survey, a radiological profile of the area will be summarized.

In July 1970 the resident liaison officer was transferred from Patrick AFB to SERHL at Montgomery, where liaison duties continued. In November and December preparations were made for the support of the NASA Mission,

Apollo 14. These preparations, similar to those for Apollo 12 and 13, included planning meetings and participation in the Launch Countdown Demonstration Test. Successful completion of these preparations demonstrated that the relocation of the liaison officer had not reduced the effectiveness of support operations.

11. RADIOTOXICOLOGY INFORMATION CENTER

The Radiotoxicology Information Center was originated as a special type of poison control center to provide information on the toxicology of radiation and radionuclides, and management of radiation accidents and side effects. A pilot project was undertaken to develop efficient methods of literature searching and classification for rapid retrieval. It was demonstrated that such a center on a larger scale is feasible.

Literature searches on the 25 isotopes listed below were conducted using Nuclear Science Abstracts (NSA) as the major reference source. As the number of references increased, it was evident the mechanical retrieval system (Fig. 11.1) originally used was incapable of handling the

Figure 11.1 Mechanical retrieval system used by Radiotoxicology Information Center

magnitude of information required. Research indicated that the expense of placing the Radiotoxicology Information Center on a computer system at the present geographical location would be prohibitive. Therefore, inquiries were made with the hope of adding the Radiotoxicology Information Center to an existing or planned center that would have access to the NSA tapes.

Isotopes in the Center

Calcium-45	Krypton-85	Sulphur-35
Carbon-14	Lead-210	Technetium-99
Cesium-137	Molybdenum-99	Thorium-232
Cobalt-60	Phosphorus-32	Tritium
Gold	Plutonium-239	Uranium-238
Indium-133	Potassium-40	Xenon-133
Iodine-131	Radium-226	Zinc-65
Iridium-192	Sodium-24	
Iron-59	Strontium-90	

To prove the feasibility of the NSA tapes as the source for the information center, a sample inquiry concerning the radiotoxicology of ^{147}Pm was submitted to the AEC at Oak Ridge, Tennessee. The results of their literature search were examined and found to be quite adequate.

The Center was represented at the workshop of the Study of Environmental Quality Information Programs (SEQUIP) in the Federal Government, held in Washington, D.C., on May 18-19, 1970, at the request of the Office of Science and Technology, Executive Office of the President. The Center was the only information program of its type represented at this workshop.

It is recommended this worthwhile project be carried on by a large, adequately equipped center.

12. PUBLICATIONS AND PRESENTATIONS OF SERHL STAFF --1970

Publications

BEDROSIAN, PAUL H. and GERALD L. GELS. Laboratory examination of a ruptured 50-mg radium source. BRH/SERHL 1970-1, PB 191 810 ($3.00) National Technical Information Service, Springfield, Va. 22151

BROOKS, I.B., G.A. LUSTER, and D.G. EASTERLY. A procedure for the rapid determination of the major cations in milk by atomic absorption spectrophotometry. Atomic Absorption Newsletter 9(4):93-94 (1970)

LIEBERMAN, ROBERT and A.A. MOGHISSI. Low-level counting by liquid scintillation. II. Applications of emulsions in tritium counting. Int. Jour. of Appl. Rad. and Isotopes 21:319-327 (1970)

MOGHISSI, A.A. and ROBERT LIEBERMAN. Tritium body burdens of children, 1967-1968. Rad Health Data & Reports 11(5):227-231 (1970)

MOGHISSI, A.A. and R.J. Lyon. Tritium concentrations in food, 1967-1968. Rad Health Data & Reports 11(5): 233-236 (1970)

MOGHISSI, A.A., E.D. TOERBER, J.E. REGNIER, M.W. CARTER and C.D. POSEY. Health physics aspects of tritium luminous dial painting. Health Physics 18:225-261 (1970)

MOGHISSI, A.A. Analysis and public health aspects of environmental tritium. Advances in Chemistry Series, No. 93, "Radionuclides in the Environment" pp. 419-426, American Chemical Society (1970)

MOGHISSI, A.A. and CHARLES R. PORTER. Tritium concentration in precipitation, 1967-1968. Rad Health Data & Reports 11(3):137-140 (1970)

MOGHISSI, A. A. Low-level liquid scintillation counting of alpha- and beta-emitting nuclides. Chapter 7 in The Current Status of Liquid Scintillation Counting, edited by Edwin D. Bransome, Jr., M.D., Grune and Stratton, Publ., N.Y. pp. 86-94 (1970)

REHNBERG, G. L., A. A. MOGHISSI, and E. W. PEPPER. Effects of microwaves on optical activity. Proceedings of a Symposium "Biological Effects and Health Implications of Microwave Radiation" Richmond, Va., Sept. 17-19, 1969 BRH/DBE 70-2, PB 190 110 (1970)

SHUPING, R. E., C. R. PHILLIPS, and A. A. MOGHISSI. Krypton-85 levels in the environment determined from dated krypton gas samples. Rad Health Data & Reports 11(2):671-672 (1970)

SOUTHEASTERN RADIOLOGICAL HEALTH LABORATORY Technical Report, "Radium--Safety, Storage, Research at the Southeastern Radiological Health Labcratory" GPO 979-918 (1970)

Presentations

Introduction to Microwave Energy: Principles and Applications. Wm. A. Herman, presented to Alabama State Sanitarians, Montgomery, Ala., Feb. 26. 1970

Evaluation of Radar Hazards. Ronald L. Shearin, presented at Natl. Conf. on Radiation Control, W. Palm Beach, Fla., April 28, 1970.

Evaluation of Rapid Field Method for the Collection of Radionuclides from Milk. Ann B. Strong, Charles R. Porter, Paul H. Bedrosian, presented at Health Physics Soc. Ann. Meeting, Chicago, Ill. June 28-July 2, 1970

Introduction to Microwaves - Principles, Applications and Problems. R. E. Shuping, presented to State Sanitarians of South Carolina, Sumter, S. C. Aug. 27, 1970

Rapid Determination of Plutonium in Environmental Samples. F. E. Butler, R. Lieberman, U. R. Moss and A. B. Strong, presented at 16th Ann. Bioassay & Analyt. Chem. Conf., Bethesda, Md., Oct. 8-9, 1970

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The ABSTRACT CARDS below are designed to facilitate document retrieval using Coordinate Indexing. They provide space for an accession number (to be filled in by the user), suggested keywords, bibliographic information, and an abstract.

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Eastern Environmental Radiation Laboratory: ANNUAL REPORT OF THE EASTERN ENVIRONMENTAL RADIATION LABORATORY January - December 1970
U. S. Environmental Protection Agency, Publication No. EERL 71-4 (October 1971) 76 pp. (limited distribution).
ABSTRACT: Significant studies were undertaken by the SERHL during 1970 and were concerned with several areas. Enactment of PL 90-602 led to the initiation of two major projects within the Laboratory--study of microwave biological effects and construction of a calibrated microwave irradiation facility. Another project was concerned with identifying radionuclides found in an impounded cooling lake for a nuclear power
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plant. Radiochemistry research investigated several areas particularly in environmental surveillance. Environmental Surveillance Networks continue to provide data on environmental radiation exposure. The radium storage inventory exceeds 56 grams, while an improved photographic leak testing device was developed as was a new radon monitor. Technical training was provided to 391 persons in courses conducted by the SERHL training program.

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